Geophysical Research Abstracts
Vol. 13, EGU2011-5793, 2011
EGU General Assembly 2011

Modeling the long term dynamic and damage of large rockslides

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The risk associated with deep-seated gravitational slope deformation hazard is of major concern in a lot of mountainous regions. Understanding the long-term dynamic of these large rockslides is therefore a main objective to assess the potential risk of failure.
Some rockslide datations provide exposure age during Holocene when conditions were warmer and wetter, and corroborate the hypothesis of climatic trigger to understand the origin of the failure. However, recent cosmogenic datation sequences on Séchilienne and La Clapière rockslides (French Alps) show their long and complex time-evolution, with progressive acceleration over many thousands of years. Those sequences thus question the triggering factors of these large rockslides.

The rockslide dynamic results from a complex combination of geological, mechanical, morphological, and hydrological processes, with possible interaction with external factors as rain or earthquakes. All these processes act at different time and spatial scales, that makes the rockslide dynamic difficult to observe. Because of the relatively recent quantitative observation of rockslides, the decoupling of all these effects is still difficult. Therefore, we use numerical modeling of large gravitational deformation slopes to estimate the sensitivity of rockslide dynamic to these processes, to evaluate their characteristic time, and to better predict the slope failure.

We first develop a model of progressive damage through intact rockmass based on finite element methods. This model uses time-to-failure estimates based on rock sample creep experiments. It is able to reproduce progressive damage localization along shear bands associated with strain rate acceleration observed during tertiary creep. The model reproduces both the different phases of deformation and the typical morphological properties observed on large rockslides. We thus show that this model is adapted to simulate the dynamic of large rockslides from initiation to transition to rapid sliding.

The sensitivity of the rockslide dynamic to different mechanical properties is first analyzed. We then use the model to understand the characteristic times of different mechanical processes, like debutressing following deglaciation. We show that deglaciation can affect the morphology of the rockslide damaged area, and that the landslide time-response to deglaciation can be on the order of several thousands of years. We finally discuss the relative contribution of climatic and deglaciation processes on the triggering of rockslide.