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Ambient vibrations of unstable rock slopes – insights from numerical modeling

Jan Burjanek (1), Ulrike Kleinbrod (2), and Donat Fäh (2)

(1) Institute of Geophysics of the CAS, v.v.i., Praha 4, Czech Republic (burjanek@ig.cas.cz), (2) Swiss Seismological Service, ETH Zürich, Switzerland

The recent events in Nepal (2015 M7.8 Gorkha) and New Zealand (2016 M7.8 Kaikoura) highlighted the importance of earthquake-induced landslides, which caused significant damages. Moreover, landslide created dams present a potential developing hazard. In order to reduce the costly consequences of such events it is important to detect and characterize earthquake susceptible rock slope instabilities before an event, and to take mitigation measures. For the characterisation of instable slopes, acquisition of ambient vibrations might be a new alternative to the already existing methods. We present both observations and 3D numerical simulations of the ambient vibrations of unstable slopes. In particular, models of representative real sites have been developed based on detailed terrain mapping and used for the comparison between synthetics and observations. A finite-difference code has been adopted for the seismic wave propagation in a 3D inhomogeneous visco-elastic media with irregular free surface. It utilizes a curvilinear grid for a precise modeling of curved topography and local mesh refinement to make computational mesh finer near the free surface. Topographic site effects, controlled merely by the shape of the topography, do not explain the observed seismic response. In contrast, steeply-dipping compliant fractures have been found to play a key role in fitting observations. Notably, the synthetized response is controlled by inertial mass of the unstable rock, and by stiffness, depth and network density of the fractures. The developed models fit observed extreme amplification levels (factors of 70!) and show directionality as well. This represents a possibility to characterize slope structure and infer depth or volume of the slope instability from the ambient noise recordings in the future.