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Optimizing seismic monitoring for landslides by using on-site artificially generated signals

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We develop a methodology for the optimization of seismic arrays used for landslide monitoring. We design an experimental field set-up that generates signals caused by soil friction, such as those during a landslide. The set-up allows for controlling the normal stress, moisture content and the size of the slippage interface area. The optimization is based on the frequency and energy content analysis of the emitted artificial landslide signals and how local geology affects them. This can significantly improve the detection threshold of the monitoring system, the design of which, to-date, is mainly based on speculations for the site conditions or expensive borehole logs and its optimization on time-consuming trial and error procedures.

We use a concrete cylinder, 0.5m high and 0.65m wide filled with high porous tropical clay excavated from the experimental site. The cylinder is placed on a 4m long, 2m wide clay strip, free from any surficial vegetation. As the cylinder is moved horizontally along the corridor, soil friction generates signals. By varying the load applied by the material within the cylinder we simulate slippage at different depths. Five different normal stress levels between 11.9kPa and 22.5kPa, corresponding to depths of 0.7 and 1.4m respectively, are simulated. The load applied on the slippage surface is the only variable, thus allowing the investigation of the normal stress effect on the emitted signals. The experiment is completed within 3 hours, under the same weather conditions. Therefore, no changes in the clay, i.e. moisture content, take place. We minimize the ambient noise by performing the experiment during the night.

For the monitoring of the generated seismic signals we use 12 short period 3-component seismometers with natural frequency of 2Hz. Eight sensors are deployed as a linear array (spacing between them is 1 to 2m with the first and last sensors being 2m and 15m away from the strip, respectively) perpendicular to the direction of movement of the cylinder. The remaining sensors are deployed around the strip at a 5 to 10m radius.

We discriminate between the soil friction signals and ambient noise. The analysis reveals a frequency content below 150 Hz for all normal stress levels examined. The attenuation of the signal is large, with the signal amplitudes halved for the sensors that were 15m away. Furthermore, the increase of stress didn't affect greatly the emitted seismic signals meaning that it might not be an important parameter at our local geology.

The suggested methodology can be used as a site investigation tool for the seismic study of real landslides. It is site specific and can be adapted to simulate different landslide conditions. It is a low cost, fast methodology that can provide information on the detection threshold of the seismic monitoring system, the effect of the on-site soil conditions on the seismic signals, and on signal pattern recognition prior to the final design of the monitoring system and its deployment.