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Characterization and comparison of seismic signals emitted during field scale sheer box experiments and artificially induced landslides

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The identification and detection of landslide induced seismic signals, recorded by deployed seismometers on active landslides has been the subject of many studies. The most commonly faced problem is the uncertainty in identifying which of the recorded signals are representing a movement or a failure in the landslide's body. In this paper we present two novel experimental campaigns; 1) field scale laboratory experiments of a 65cm diameter sheer box, 2) artificially induced failure of two, two-meter high vertical soil slopes.

Using a field scale sheer box we recorded seismic signals emitted during soil slippage events, a phenomenon observed at a landslide's failure plain. This was implemented by displacing, a few centimeters at a time (1-10cm), a concrete cylinder filled with soil along a corridor free from vegetation. The field scale sheer box methodology allows control over a large number of parameters that affect a landslide. For example, it is possible to control soil saturation thus simulating different rain events or control the stress field on the soil's slippage surface simulating displacement events at different depths. More than 40 displacement events were induced under four different loading conditions between 472kg to 829kg. All soil slippage events were recorded above the levels of background seismic noise. Repetition of the methodology under the same experimental conditions resulted in similar seismic signals allowing us to define a 'characteristic seismic response' for soils.

In the second experimental campaign, two controlled landslides were experimentally induced by increasing the vertical load on top of a 2m soil scarp. We were able to detect from 1 to 10 centimeter wide crack propagations and displacements, and approximately 20x20x10cm to 100x50x20cm block failure events based on microseismic recordings, field notes, video recordings and displacement measurements of the landslide's crown that failed during the experiments. Direct correlation between these visual recordings with seismic signals produced unique frequency patterns. Scanning all seismic data searching for these patterns allowed for detection of displacement events within the recordings that were not observed visually and were likely located within the landslide's mass.

Both experimental campaigns were recorded by short period 3D seismic sensors. In order to validate the signals emitted using the sheer box methodology we compared them to the small displacement events recorded in the landslide experiments in the frequency domain by calculating their power spectral densities. Our results show close similarity between the two, validating the field scale lab experiment as a tool for preliminary understanding of the expected seismicity of an active landslide.

Our study demonstrates the potential of microseismic motoring for detecting small soil displacements and soil block failures above ambient noise levels, as part of an active landslide monitoring campaign. Future research will use these results to design a monitoring network based on the threshold for event detection, which is a function of the displacement rate and the source-to-receiver distance. To our knowledge these are the first controlled field experiments that can allow validation and calibration of seismic monitoring for landslide detection.