



Seismic noise parameters as precursors to slope rupture: a review

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Continuous seismic monitoring systems have been increasingly used for monitoring gravitational movements of all types. On the one hand, they allow studying the seismicity induced by mass movement and in particular, identifying and locating the generated micro-earthquakes. On the other hand, continuous recording also able to measure the ambient seismic noise, the properties of which depend on site conditions and can be investigated for site characterization.

Both data (induced seismicity and seismic noise) have been used for monitoring instable slopes and looking for instability precursors. In the few sites where a seismic monitoring system was operating at the time of the slope rupture, an increase in seismic activity was generally observed before the movement. In rigid rocks, these seismic activity precursors may however remain stable until a few days, and sometimes a few hours, prior to the rupture, making hazard assessment difficult. The monitoring of seismic noise properties has been developed more recently, allowing to track variations in internal mass characteristics as a function of time. For clayey landslides likely to evolve to earthflows or mudflows, it has been shown that the shear wave velocity (V_s) significantly decreased with the material damaging. The V_s evolution at depth can be followed by cross-correlating the seismic noise records at two seismometers, using the variation in surface wave velocities at different frequencies. In rock conditions with cliff morphology, seismic noise records on a prone-to-fall column may easily provide the column resonance frequencies that are controlled by the volume and elastic properties of the unstable mass, as well as the stiffness of the contact with the adjacent stable rock mass. With the decoupling of the column and its mechanical degradation with time, these resonance frequencies progressively decrease before failure.

In this work, we make a review of the few published cases where seismic noise properties were measured until the slope rupture and present a recent data set for which several precursory parameters based on seismic noise and activity were monitored. We critically analyze the precursory patterns, attempt to draw conclusions on the reliability of these methods for monitoring purposes and identify future prospects.