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Understanding pre-failure deformation in non-cohesive soils using analogue models

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Current challenges in landslide forecasting include the development of new techniques to predict rockfalls in natural slopes using a certain precursory indicator as precursory rockfalls leading to larger failures, micro-seismic events, precursory deformation, etc. Regarding small scale pre-failure deformation leading to larger failures, current techniques fail to detect this indicator due to insufficient data accuracy and/or low temporal resolution (infrequent data acquisition).

To understand the precursory phenomena in non-cohesive soils, we carried out a series of experimental tests with analogue model. These tests are realized in a sandbox with both sides made of glass, allowing visualisation of the failure planes. For the simulation, a 50 cm vertical slope was built with quartz sand with a fixed percentage of bentonite. Measurements were carried out using 3D remote sensing techniques (Konica digitizer Minolta Vivid 9i) to acquire to acquire high accuracy (± 0.05 mm) and high resolution (± 0.01 mm) 3D information of surface topography at a very high data acquisition speeds (300'000 pts/2.5 sec). Slope evolution was obtained through a temporal comparison of datasets using PolyWorks (shortest distance comparison method).

As regards slope evolution, we measured precursory displacements at discrete parts of the slope using a newly developed algorithm that allows tracking spherical targets along time. The main steps of the algorithm are: (a) A point filter based on sphere color; (b) the use of a sphere fitting function for the detection of the spheres on each dataset; (c) measurement of a series of displacement vectors in discrete parts of the slope. To this end, we computed the displacement of the centre of each sphere for all the temporal series of scans; (d) validation with manual measurements. Results of the algorithm shows close resemblance to reality (σ = 0.33 between computed and real position).

Results of the precursory deformation evolution are compared to the slope evolution of a natural rock slope measured with a Terrestrial Laser Scanner, showing the importance of using series of high temporal resolution datasets in order to better understand the slope evolution.