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Monitoring of landslide deformation during controlled rainfall experiments using a long-range terrestrial laser scanning (TLS)

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Terrestrial Laser Scanning (TLS) has been used to monitor landslide displacements during two experiments of controlled rainfall in order to detect minor deformation which can be correlated with hydrological measurements.

The controlled rainfall experiments were performed on two clay-rich landslides located in the southern French Alps (the Super-Sauze mudslide in the Ubaye valley and the Laval landslide in the Bouinenc valley) in order to better understand the factors controlling their hydrology and their mechanics. Both landslides are developed in clay-shales (black marls), have no vegetation cover and several common geomorphological, geological and geotechnical characteristics. However the Laval landslide is in an earlier stage of development than Super-Sauze, with steeper slope gradients (mean slope of 32^o for Laval, mean slope of 25^o for Super-Sauze).

Controlled rainfall experiments were performed during several days on plots of about 120 m^2 (7 x 14 m) with a mean intensity of 15 mm.h^{-1}. Several geophysical parameters were monitored (soil humidity, soil temperature, pore water pressure, soil electric resistivity, acoustic velocity, water quality). Soil deformation was monitored by TLS with an OPTECH Ilris3D laser scan. On the Super-Sauze mudslide, the laser mapping was conducted over 5 days from July 10-14, 2007 (an acquisition per day). Three consecutive scans (representing an acquisition) were necessary to mini-

mize the shadow zones and to expand the range and density of point data which is less than 1 laser point.cm^{-2}. On the Laval landslide, the laser mapping was conducted over 4 days from October 09-12, 2007, by applying the same TLS parameters as in Super-Sauze. The processing was performed using PolyWorks 10. For Super-Sauze, the scans were fitted on a stable area (fitting accuracy $\pm$ 1 cm). The same procedure was not possible for the scans of Laval landslide, they were only fitted and compared thanks to benchmark overlaying (fitting accuracy $\pm$ 2 cm).

In Super-Sauze, the displacements inside the infiltration plot are quite homogenous and are perfectly displayed by the piezometers displacements which vary from 10 up to 15 cm in five days. It is shown that the shear rate can be considered as a constant for the first three meters of depth during the time of experiment. By considering the movement of the area outside the infiltration zone, the magnitudes of benchmarks displacement are very similar with those of the piezometers. It suggests that no deformation is directly linked to the controlled rainfall experiment. However it must still be verified by statistical comparisons of the displacements inside and outside the infiltration zone. At the Laval slide, after one day of rain experiment, the entire zone collapsed of 2 to 5 cm and stayed at this level during the following days. This may be explained by a fast response of the soil to rainfall at the Laval slide. The difference of behavior between the Laval and Super-Sauze landslides could be explained by different hydrological conditions.

The results using TLS show how high quality and quantity of points help to monitor displacements at the scale of the study. They show also the systematic need to fit the scan on a stable area to maximise the accuracy. Further works will be done to complete these interpretations with geomechanical and geophysical measurements to finally contribute to a better risk assessment.