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Characterization of landslide kinematics with a long range terrestrial laser scan: a methodological approach

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The objective of this work is to present a methodology for analyzing large displacements of landslide with a terrestrial laser scan (TLS) and to characterize the acquisition and computation errors of the displacement fields. Several high resolution TLS observations (0.3 to 4 pt.cm^{-2}) were acquired in representative plots of the Super-Sauze mudslide in 2007 and 2008: the main scarp in the upper part, the medium part exhibiting the highest displacement rates and the toe in the lower part. The TLS equipment is an Optech ILRIS-3D. All the processing has been performed with the Polyworks software.

Among the procedures influencing the quality of the derived displacement fields, the alignment of the scans is the most sensitive. The distribution of statistical noise associated to equipment errors follows a normal law and does not significantly influence the quality of the displacement field (μ = 0.1 cm, σ = 1.0 cm). As well, local changes in surface soil moisture do not significantly influence the quality of the displacement field; although the intensity of the signal is drastically decreased (∼24% of the maximum intensity), observations on nearly saturated and unsaturated plots still indicate a tolerable error band of μ = 0.3 cm and σ = 0.2 cm at a distance of 30 m from the laser scan.

To quantify the displacement field from the original point clouds, several approaches can be used: (1) point cloud comparisons (e.g. algorithm looking for the shortest points along a vector), (2) rebuilding of object geometry (TIN model analysis), and (3) difference of DEMs. In order to characterize displacements with an important horizontal component, it is demonstrated that the object recognition method is more efficient to characterize the kinematics on relative smooth topography than point clouds algorithms.

To characterize displacement with a more important vertical component, such as the collapse of material from the main scarp of the mudslide, a "jackknife" procedure was used to identify the best interpolation techniques for producing the DEM. A differential DEM analysis allowed to define the volume of the collapse (∼23.000 m^3) as well as a progressive subsidence of the area downslope.

The quality of the alignment is the most sensitive parameter influencing the accuracy of the laser scan observations. A good coverage among the scans and the inclusion of stable parts are necessary to maximize the alignment procedure, but the number of scans to acquire has also to be minimized in a survey planning.