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Characterization of the 3D displacement field of landslides from Terrestrial Laser Scanning using 2D cross-correlation technique

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The characterization of the complete displacement field is an important prerequisite to understand landslide kinematics and failure mechanism. In this last decade, the potential of Terrestrial Laser Scanning (TLS) to monitor slow-moving landslide has been largely demonstrated but methodologies are still needed to fully exploit the TLS point clouds to derive interpretable 3D displacement fields.

In this work, a new and simple approach is presented using repeated TLS acquisitions by taking full advantage of the geometric information from consecutive point clouds. The performance of the approach is being tested at the toe of the Super-Sauze mudslide (South French Alps) where ten TLS acquisitions were acquired over the period October 2007 - May 2010 from the same base position at a distance of about 100 m.

The core of the approach is based on the simplification of a 3D matching problem in a 2D matching problem by using a 2D statistical normalized cross correlation function. The point clouds are first filtered from vegetation and co-registered in a common local coordinate system by aligning the TLS acquisitions on stable parts in the surrounding of the landslide (3D accuracy of 0.03 m, 1σ). A back projection is then applied to project and interpolate the 3D point clouds on a 2D regular grid perpendicular to the viewing direction of the scanner using the collinearity equations. In order to emphasize the relief morphology projected in the 2D grid, the 2D gradient of the distance separating the point clouds from the TLS location is computed and correlated. The re-projection of the correlated displacements in the 3D local coordinate system allows to reproduce the 3D displacement field and to compute the strain field using a linear approach.

The obtained results show that the proposed approach is very promising. Comparisons with 3D displacements computed with the classical 3D roto-translation technique using an Iterative Closest Point algorithm and benchmark displacements measured with Differential Global Positional System allow to compute an average accuracy of 0.03 m.

Displacements of the mudslide toe ranging from 0.04 m to 10.76 m between consecutive TLS acquisitions are determined, leading to a cumulated displacement up to 21.80 m from October 2007 to May 2010. Areas in the mudslide toe with different kinematics (parts under extension or compression) can be highlighted by the mean of a strain analysis.