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Observation of landslide kinematics using correlation of terrestrial oblique optical images.

Julien Travelletti (1), Jean-Philippe Malet (1), Jean Schmittbuhl (1), Renaud Toussaint (1), Christophe Delacourt (2), Bas van Dam (3), and Mickael Bastard (1)

(1) School and Observatory of Earth Sciences, Institute of Earth Physics, Strasbourg, France (julien.travelletti@unistra.fr, +33 (0)3 68850114), (2) Université Européenne de Bretagne, Institut Universitaire Européen de la Mer, CNRS UMR 6538, University of Brest, Brest, France, (3) Faculty of Geosciences, Department of Physical Geography, Utrecht University, Utrecht, Netherlands

The objective of this work is to present a method to monitor the displacement pattern of slow-moving landslides from terrestrial oblique optical images analyzed with a Digital Image Correlation (DIC) technique. The performance of the method is evaluated on a serie of images acquired on the Super-Sauze landslide (South French Alps) which exhibits velocities from 0.01 to 0.4 m.day-1.

The image monitoring system consists in a low cost high resolution optical camera installed on a concrete pillar located on a stable crest in front of the landslide (oblique view) and controlled by a datalogger. Every 4 days, photographs are registered at 11:00 AM, 12:00 PM, 13:00 PM and 14:00 PM.

To estimate the planimetric ground displacement that occurred between several images acquired over the same area at several different times, a local window of a variable number of pixels is defined on the oldest image; then, the corresponding window is searched on the more recent image by maximizing a correlation function using a multi-resolution approach. This process is iterated for each pixel of the oldest image of the complete time serie. In our case, a serie of 108 multi-temporal images has been correlated over the period June 2007 – July 2009. Quality of image co-registration is evaluated for each image.

The results of the correlation are first interpreted qualitatively in the image plane of the camera in terms of pixel displacement and direction. Then, a method using projective transformation is used to associate the pixel coordinates of the image plane to ground coordinates in the local field coordinate system using DEMs interpolated from airborne LiDar datasets. In the transformation, we assume that the global morphology of the landslide is nearly invariant in time.

In the image plane of the camera, the displacement pattern is clearly identified. The average residual pixel shift on the stable part is used to calculate an uncertainty usually less than 1 pixel after correction of slight rigid movements of the camera. The amplitude and direction of pixel displacements indicate displacement fields with different kinematics between the upper and the lower part of the landslide. After transformation in the ground coordinates, the maximum of displacement amplitudes could be identified in spring 2008 after important rainfall and snow melting. During that period, the maximum of average horizontal velocities reached 2.62 ± 0.03 m.day-1 in the upper part and 0.27 ± 0.03 m.day-1 in the lower part (the average velocities are calculated over 4 days of displacements).

Displacements maps are created for each pairs of images; they indicate that the kinematics is mainly controlled by the burried topography of the landslide. Two years of spatially distributed displacement patterns are presented and compared with control points measured with dGPS. Inversion of the displacement field is developed to characterize the macroscopic geomechanical properties of the landslide material.