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4D very high-resolution topography monitoring of surface deformation using UAV-SfM framework.

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During the last years, exploratory research has shown that UAV-based image acquisition is suitable for environmental remote sensing and monitoring. Image acquisition with cameras mounted on an UAV can be performed at very-high spatial resolution and high temporal frequency in the most dynamic environments. Combined with Structure-from-Motion algorithm, the UAV-SfM framework is capable of providing digital surface models (DSM) which are highly accurate when compared to other very-high resolution topographic datasets and highly reproducible for repeated measurements over the same study area.
In this study, we aim at assessing (1) differential movement of the Earth's surface and (2) the sediment budget of a complex earthflow located in the Central Swiss Alps based on three topographic datasets acquired over a period of 2 years.
For three time steps, we acquired aerial photographs with a standard reflex camera mounted on a low-cost and lightweight UAV. Image datasets were then processed with the Structure-from-Motion algorithm in order to reconstruct a 3D dense point cloud representing the topography. Georeferencing of outputs has been achieved based on the ground control point (GCP) extraction method, previously surveyed on the field with a RTK GPS. Finally, digital elevation model of differences (DOD) has been computed to assess the topographic changes between the three acquisition dates while surface displacements have been quantified by using image correlation techniques.
Our results show that the digital elevation model of topographic differences is able to capture surface deformation at cm-scale resolution. The mean annual displacement of the earthflow is about 3.6 m while the forefront of the landslide has advanced by ca. 30 meters over a period of 18 months. The 4D analysis permits to identify the direction and velocity of Earth movement. Stable topographic ridges condition the direction of the flow with highest downslope movement on steep slopes, and diffuse movement due to lateral sediment flux in the central part of the earthflow.