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Comparative study of landslide mapping on UAV and TLS derived point-clouds: A case study in Anilio, Greece

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Introduction

Landslide phenomena pose a major threat to humans and the environment. Due to the complex nature of landslides, a thorough investigation is essential in order to identify and study such disastrous phenomena. The incorporation of innovative tools, such as Unmanned Aerial Vehicles and Terrestrial Laser Scanners is proved to be very effective in the investigation process, in terms of precision, and time-efficient. Moreover, the use of remote sensing techniques in landslide surveys provides information that covers a variety of applications, such as landslide identification and mapping, monitoring, susceptibility and hazard assessment (Scaioni M. et al., 2014). This study, by employing both a UAV Photogrammetry and a Terrestrial Laser Scanning approach for data acquisition, focuses on landslide identification and mapping in a vegetated area and provides a comparative analysis of the mapped landslide features on both, UAV and TLS-derived, point-clouds. It is noted that besides the use of these tools, a field investigation was conducted, in order to evaluate the results derived from the point-clouds.

Study area

The study area is located in Anilio village, in the prefecture of Epirus, Greece. According to the geotectonic zonation of Greece, the area appertains to the zone of Olonos-Pindos, which is composed of Mesozoic carbonate and siliciclastic rocks and Tertiary flysch formations. Pindos flysch consists mainly of sandstones, siltstones and their alternations repeated in several thrust sheets with NW-SE direction. Flysch, in general, is characterized by heterogeneity, presence of members with low strength and a complex structure due to folding, shear zones and discontinuities (Marinos et al., 2015). Therefore, its behaviour in slope stability is controlled by these factors in connection with the regional setting, such as morphological and groundwater conditions. The area of interest is formed entirely in a flysch environment, with siltstone formations being predominant, and strongly tectonized by numerous thrusts, being in very close proximity to the Pindos ophiolite nappe, resulting in the degradation of the original rock mass quality.

Methodology

In order to collect the information, a combination of methods was applied. During a visit in the study area, alongside with in-situ investigation, data were collected using an Unmanned Aerial Vehicle and a ground-based LiDAR system. A series of overlapping high resolution images of the area of interest were acquired by the UAV following a predefined flight path. UAV photogrammetry was used in combination with the Structure from Motion technique, as very detailed 3D models can be obtained from overlapping imagery with SfM algorithms (Lucieer et al., 2014). UAV imagery was used in the SfM workflow in a software environment and was automatically processed, resulting in the generation of a point-cloud, a Digital Surface Model (DSM) and an orthomosaic. Consequently, a hillshade map was produced, where two main landslides in the region of Anilio are depicted (Figure 1). Furthermore, data were collected by a TLS using the Time of Flight principle for ranging. In order to cover the whole scene and avoid occluded areas, several scans from different points of view are needed (Jaboyedoff et al., 2018). For that purpose, scans were conducted from two different positions. Later, with the aid of a point-cloud processing software (CloudCompare 2.10.2), point-clouds from the multiple scans were used as input and were manually merged in order to generate a single point-cloud of the landslide area.

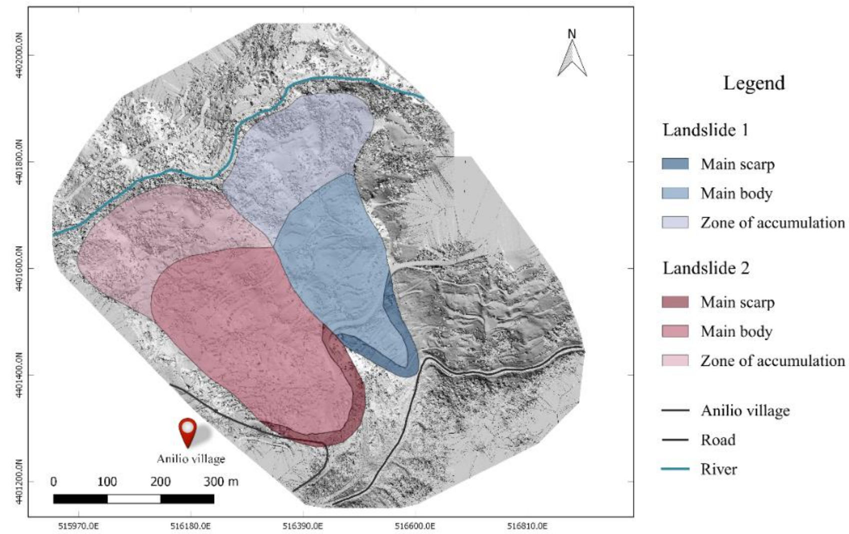

Figure 1. Hillshade map depicting two main landslides in the region of Anilio.

Results

The two point-clouds, one derived from UAV data and one derived from TLS data (Fig. 2), were used in order to detect geomorphological features of typical landslides, such as scarps, depressions and zones of uplift. These features were identified and mapped on both point-clouds and were later compared. An accuracy assessment of the resulted segments was conducted in order to verify the efficiency of each approach in a densely vegetated area. The main difference between the two methods, which reflects on their derivatives, lies in the fact that the UAV method uses a passive sensor and LiDAR technology uses an active sensor. More specifically, the laser scanner acts as a source of illumination, emitting laser beams, whereas the UAV camera, as a passive sensor, can only capture the scene lit by natural light. This means that, LiDAR technology offers an advantage in landslide studies in vegetated areas as it can penetrate vegetation and reach the ground surface. However, this may not be possible in areas with dense tree canopy and vegetation, but such features can be removed from a TLS point-cloud in a software environment. As a result, the TLS derived point-cloud (Fig. 2a) is free of colour and consists of ground points, from the reflection of the ground surface, and non-ground points, from the reflection of trees and vegetation which can be manually removed. The UAV derived point-cloud is colour coded, meaning each point has an RGB value attributed to it and is not free of vegetation as it is produced by imagery processing (Fig. 2b). This means it is not easy to identify the geomorphological features of the landslide. Even if filters are applied, to extract the vegetation, or if they are manually removed, shadows will be still shown in the point-cloud.

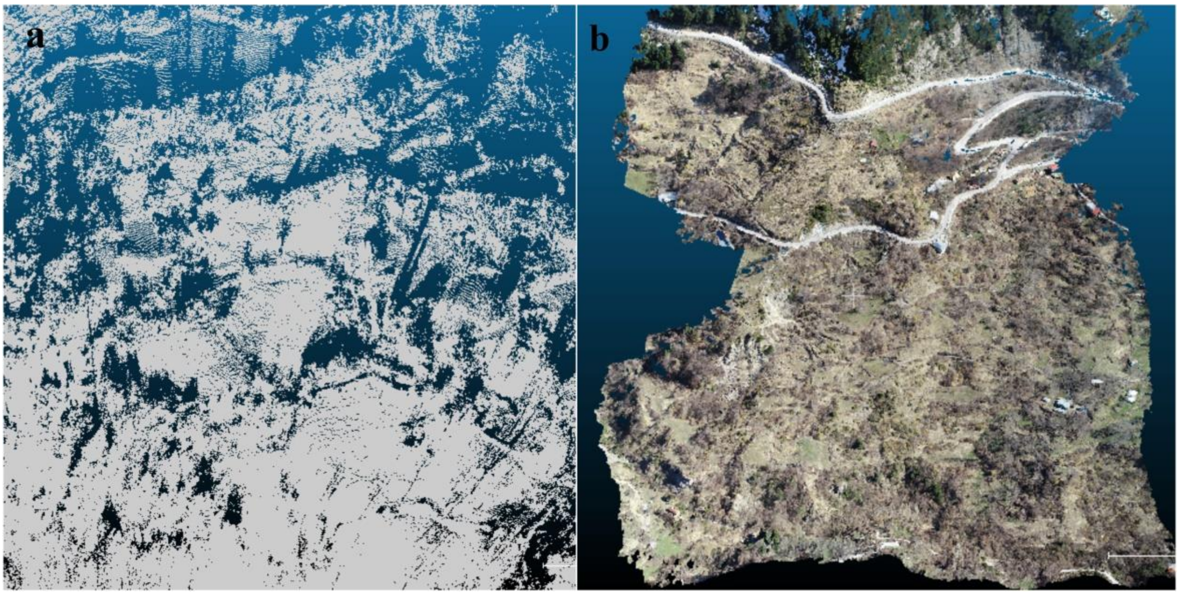

Figure 2. a)TLS-derived and b)UAV-derived point-cloud of the area of interest.

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