Engineering Geological Mapping of Earthquake-Induced Landslides in south Lefkada Island, Greece Using UAV; Applications and Limitations

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Introduction

A strong, shallow depth, earthquake (Mw=6.5) occurred onshore Lefkada island on November 17, 2015 with the focal depth estimated at 10 Km (Ganas et al., 2016). Lefkada has been repeatedly struck by earthquakes during the last century (1911-2015). The surface magnitude (Ms) of instrumentally recorded earthquakes ranges between 5.3 and 6.4. (Papathanassiou et al., 2005; 2017). The 2015 seismic fault is a near-vertical strike-slip fault running along the western coast, which is part of the CTF zone (Cephalonia Transform Fault). Landslides and ground cracks were mainly reported at the western part of the island, inducing structural damages. High severity slope failures occurred at Egremnoi and Gialos areas that both are located at western coastal regions. This study aims to investigate the engineering geological conditions at those areas assigned based on GSI classification, and assess the characteristics and physical quantities (eg. type, area-m2, volume-m3) of the instabilities. In order to achieve this, a field survey was conducted in July 2016 and landslide characterization was conducted in Eggremnoi and Gialos areas with the use of UAV imagery in relation with engineering geological mapping (Grendas et al., 2018). Furthermore, types and dimensions of slope failures were evaluated in order to estimate the total volume of the mass movement. Structure-from-Motion models produced by UAV images (using Agisoft Photoscan software) permitted the accurate and detailed identification and mapping of co-seismic failures. Moreover, all the field data from the engineering geological mapping, have been digitized and rasterized at 5 m grid spacing using ArcGIS (Figure 2). The outcome of the present study is the precise calculation of the area-m2 and volume-m3 regarding the slope failures and the correlation among the pre mentioned failures with the existing engineering geological conditions (Figure 2, Figure 3). The limitations of UAV surveys at the specific region are also presented.

Materials and Methods

Photogrammetry is called the “technique which is used in order to be received 3D data via 2 or multiple photos of the same object, captured from different angle” (Vasuki et al., 2014). Unmanned aerial systems (UAS) have been described by different names (e.g. aerial robots) but the most common title is UAV (Unmanned Aerial Vehicle) or more simply “drones” (Colomina & Molina, 2014, Siebert & Teizer, 2014). The Digital Surface Model (DSM) of Gialos area was constructed by UAV images. We performed the UAV surveys with a DJI Phantom 3 Professional quadcopter that acquired 12MP digital images. The main advantages of a UAV survey in the study sites were:

- Surveying of remote and/or inaccessible areas.
- Rapid data acquisition and wide area coverage.
- Extraction of very high resolution topography that can facilitate volumetric calculations

Regarding Eggremnoi and Gialos areas, 144 and 139 photos of 12MP were captured and analyzed respectively, via Agisoft Photoscan Pro, producing detailed point clouds (Figure 1). DSM/orthophoto maps of the sites were also constructed (Grendas et al., 2018).

Discussion and conclusions

The use of a UAV sensor made possible the mapping of landslide boundaries as well as the mapping of some structures that were not visible from the ground during the field investigation. On the other hand, during field investigation, the determination of landslide typology is possible but not the mapping of exact boundaries. Areas with dense plant cover are not available to use as long as the correct capturing of the terrain is not possible. This is in contrast to other imaging methods in which the removal of vegetation canopy is feasible (e.g. LIDAR). Towards the interpretation of Gialos site, vegetation cover was sparse and most of the structures and landslides were visible, in contrast with Eggremnoi site where dense and high vegetation was present, diminishing ground surface visibility. However, it must be noted that the peripheral segments of DEMs present quite large deformation (due to poor overlapping), an issue that leads to non-feasible editing and interpretation.

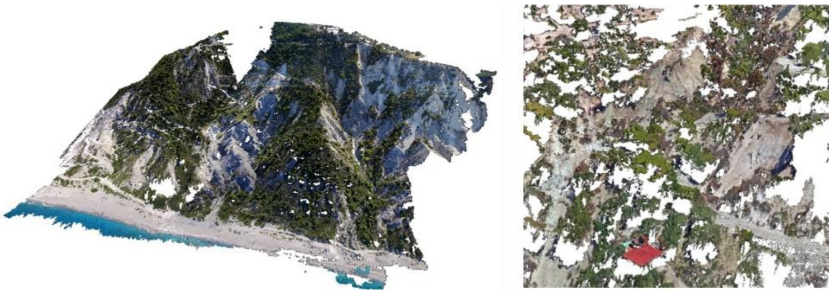

Figure 1. Structure-from-Motion models (point cloud) of the study sites from acquired UAV imagery. Left: Gialos site. Right: Close-up of Gialos site model, where frequent gaps in coverage are visible due to dense vegetation

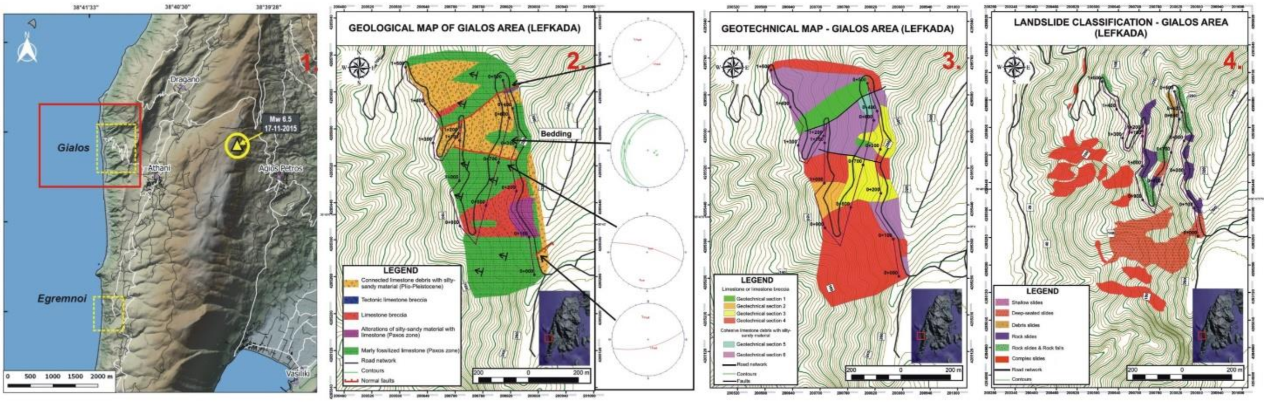

Figure 2. 1: Shaded relief map of Lefkada showing Gialos area (red square) 2: Geological map of Gialos area 3: Engineering geological map. 4: Landslide classification map produced according to DEM model

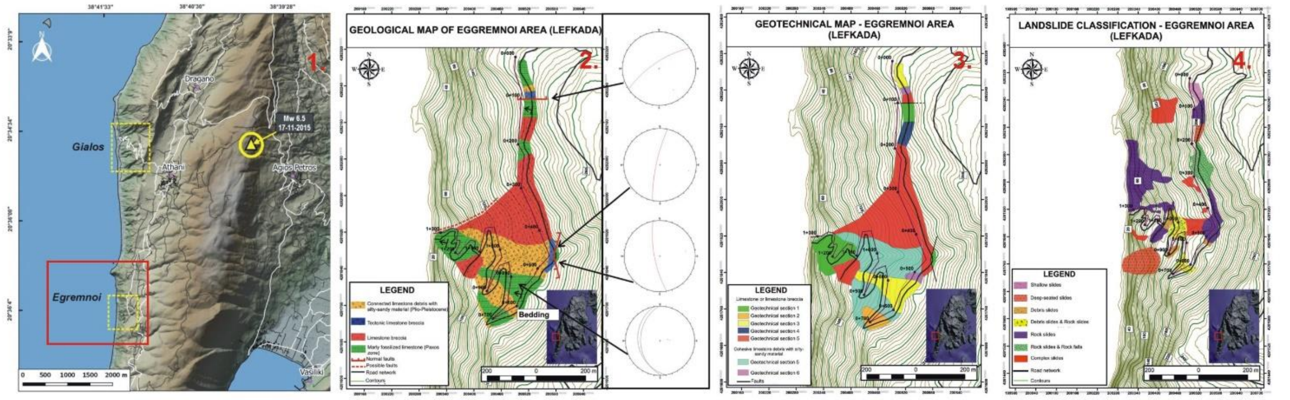

Figure 3. 1: Shaded relief map of Lefkada showing Eggremnoi area (red square) 2: Geological map of Eggremnoi area 3: Engineering geological map. 4: Landslide classification map produced according to DEM model

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