International Cartographic Association
Association Cartographique Internationale

Application of UAS for the purposes of landslide mapping in Bulgaria - a case study of the Thracian Cliff landslide, northern Bulgarian coastal zone

Lyubka Pashova[a, *], Mila Atanasova-Zlatareva[a], Hristo Nikolov[b], Grigor Nikolov[a]

[a] *National Institute of Geophysics, Geodesy and Geography - Bulgarian Academy of Sciences, lpashova.nigg@geophys.bas.bg, mila_at_zl@abv.bg, etgeonik@abv.bg*

[b] *Space Research and Technology Institute - Bulgarian Academy of Sciences, hristo@stil.bas.bg*

* Corresponding author

Keywords: Landslide mapping, Geospatial technologies, UAS, Coastal area, Northern Bulgarian Black Sea coast

Abstract:

We present a preliminary analysis of DSM/DTM from a UAS survey conducted in 2020 of the recently activated Thracian Cliff landslide located in the northern Bulgarian coastal zone. The 3D models have been generated by Px4D mapper software using the Structure-from-motion (SfM) method. The resulting high-resolution digital models can be used to map and inventory landslides and, in addition, to compile digital maps of the hazards and risks of such events across the country.

Advanced geospatial and remote sensing technologies provide opportunities for faster and higher spatial-temporal resolution of mapping reducing the time and the cost of labour-intensive field measurements. Unmanned aerial systems (UAVs) are a widely used for rapid spatial data collection that can facilitate the natural hazards mapping. This technology has quickly become a practice and is increasingly used to map and inventory landslides, in emergencies in hard-to-reach areas and at various stages of landslide risk management. Recently, in Bulgaria, this technology is used to quickly acquire spatial data and generate high-precision 3D models of the earth surface.

At a national level, a methodology for assessing the geological risk in Bulgaria was created in 2017 by the Geological Institute at the Bulgarian Academy of Science. Destructive geological processes were analysed, assessed and mapped. Maintaining and managing the national landslide databases is a responsibility of the Ministry of Regional Development and Public Works (MRDPW) and its regional centres in Pleven, Pernik and Varna. MRDPW provides public access to the produced maps of the geological hazard and risk at a scale of 1: 25,000 through the GIS web portal: http://gis.mrrb.government.bg/KGR/.

Recently, landslides on Bulgarian territory have increased due to existing geological conditions, improper land use, and anthropogenic activities. Many landslide zoning studies assume that past and present landslides are the keys to predicting future landslides. Detailed information on the location, type, date and size of past landslides and the damage caused is necessary for the proper mapping of landslides and further assessment of the hazard and risk of these natural phenomena. In particular, multidisciplinary studies are needed to monitor and reduce the adverse effects of new or activated old landslides in the Bulgarian coastal zone due to building of new infrastructure objects and tourism activities over the last three decades.

Landslide susceptibility maps for the northern Black Sea coast using the Mora and Vahrson method within the GIS environment have been compiled by Berov et al. (2020). One example of the recently activated landslide in 2014 is that, which is located near the village of Topola, Kaliakra municipality. The landslide is developed along the coastal slope, just before the entrance of the Thracian Cliffs Golf & Beach Resort. The Thracian Cliff landslide is manifested in the front of an ancient stabilized landslide “Kalkan tepe” located SE from the village of Bozhurets, according to Geozastita Varna Ltd (2018). It is ~ 550 m wide and ~280 m long in the eastern part and about 150 m in the western part (Fig.1a). The main landslide is 12-15 m high. It entered the national register of landslides with № DOB 17.05009-01-03. The main reasons for the activation of the landslide processes are the over-wetting of the earth masses by waters of unclear origin (possibly underground), leaks from the degraded sewerage built in the golf complex and the marine abrasion.

In 2020, an aerial drone survey of the Thracian Cliff landslide was performed using UAS technology to create high-precision 3D DSM/DTM models of the study area. The test aerial mapping method of the landslide aims to contribute to the complex geodetic and geological research conducted in the past 3 years (Atanasova et al., 2019; Nankin & Ivanov, 2019; Atanasova and Nikolov, 2020). Two flight plans were set with the specialized Autel Explorer software with 80% frontal and side overlap between adjacent photos to cover the whole area of the landslide. Autel EVO II 8k UAV equipped with a digital camera with 1/2 " 48MP CMOS sensor, f / 1.8 range angle, and a focal length equivalent to 25.6mm. Two flights at 120m and 140 m altitudes with a speed of 22-25 m/sec were done to achieve a pre-calculated resolution of GSD digital products of 1.5-1.8

https://doi.org/10.5194/ica-abs-3-232-2021

cm/px. Fifteen ground control points (GCPs) were marked on the site and subsequently used as photogrammetric marks to georeference the images. The GCPs were marked by temporary photogrammetric marks and coordinated by real-time GNSS RTK measurements. The geographical coordinates and heights of GCPs in the WGS'84 system (ETRS-89) were transformed respectively in the UTM35N projection and into the EVRS2007 height system. The area covered with 323 aerial images from both flights is about 28 ha.

The photogrammetric processing of all images was performed by Pix4Dmapper software following standard procedures (Pix4D, 2020). The software produced the quality check report for each processing stage. The photogrammetric range imaging technique SfM was used to calculate and optimize the data for calibration of the external and internal orientation as a basis for the production of digital products with high spatial resolution.

In the first stage, quality checks were carried out for the images, dataset, camera optimization and GCPs. The 15 GCPs were used to correct the geographical location of a project. At second stage, the density of 3D points of the 3D model was increased, which were computed in the first stage. The obtained accuracy of digital products' georeferencing is 1.3cm using GCPs. At the third stage, Digital Surface Model (DSM) (Fig.1b), Digital Terrain Model (DTM) (Fig.1c), and an orthomosaic were created (not presented here) with a spatial resolution of 5.0 cm.

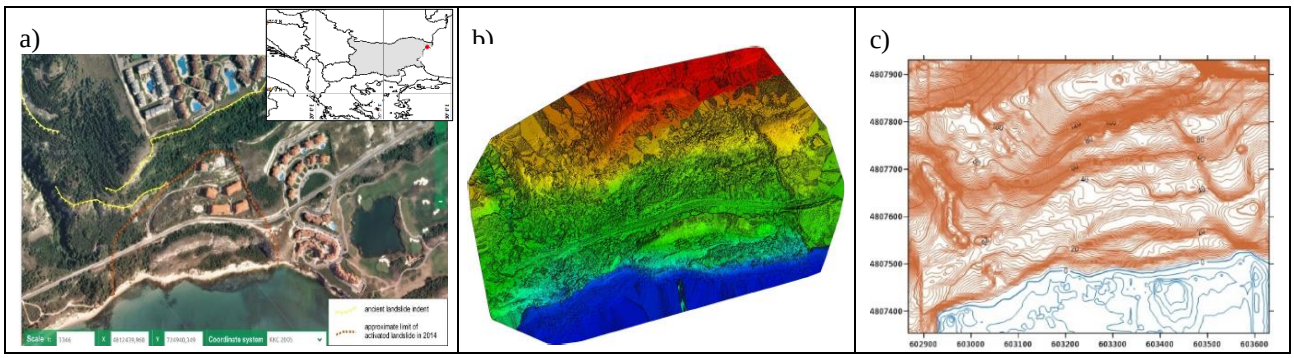

Figure 1. (a) Location of the Thracian Cliffs landslide in the northern Bulgarian coastal zone (background source: https://kais.cadastre.bg/); (b) Generated DSM in Geo TIFF format; (c) DTM with contour lines Δh = 1m.

The landslides on the northern Bulgarian Black Sea coast cause significant material damage to urban and rural settlements, agricultural and forest areas. The 3D landslide DSM / DTM models obtained in this study are accurate and detailed, providing a reasonable basis for future landslide mapping studies. Repeated photogrammetric surveys at regular intervals and their combination with results from other types of geodetic measurements and satellite data can help to properly manage the risk of landslides. To reduce damage, it is important to create landslide susceptibility, hazard and risk zoning maps, especially during the land use planning phase. Modern cheap and fast methods such as the use of UAS can be applied, which provide basic information for the production of these maps.

Acknowledgments: This study was conducted with financial support of the Bulgarian NSF under the Project № KP-06-OPR 06/1 "Monitoring of landslides on the Northern Black Sea coast of Bulgaria using data from global navigation satellite systems and interferometric aperture with synthesized equipment". The authors express their gratitude to the private company GEO+ for the realization of UAS surveying over the studied area.

References:

Atanasova M., H. Nikolov, I. Georgiev, A. Ivanov, N. Dimitrov (2019). Monitoring of landslide processes at the NE Bulgaria by joint use of GNSS and InSAR, In: Proceeding 10th Congress of Balkan Geophysical Society, 18-22 September 2019, Albena Resort, Bulgaria, EAGE, 2019, https://doi.org/10.3997/2214-4609.201902640

Atanasova, M. and H. Nikolov (2020). Integrative use of GNSS and InSAR data: a case study of landslide on the Thracian rocks coastal slope, In: Proc. SPIE 11534, Earth Resources and Environmental RS/GIS Applications XI, 115340S, https://doi.org/10.1117/12.2573641

Berov, B., N. Nikolova, P. Ivanov, N. Dobrev, M. Krastanov, R. Nankin (2020). Landslide susceptibility mapping using GIS: a case study along Bulgarian Black Sea coast, In Proc. of 8th ICC&GIS conference, (Eds.) T. Bandrova, M. Konečný, S. Marinova, Nessebar, Bulgaria, vol. 1, 287-296, ISSN: 1314-0604.

Geozastita Varna Ltd. (2018). Annual Report, Available at: https://www.mrrb.bg/bg/godishen-doklad-za-2017-g-na-durjavnoto-drujestvo-za-geozastita-varna/ (retrieved on 3 February 2021)

Nankin R., Pl. Ivanov, M. Krastanov (2020). Thracian Cliffs landslide, Northern Bulgarian Black Sea Coast, Review of the Bulgarian Geological Society, vol. 81, part 3, 215–217.

Pix4D (2020). Pix4D. Drone Mapping Software. https://pix4d.com/