MORPHOMETRICAL CHARACTERISTICS OF AVALANCHES WITH THE USE OF A UAV (ON THE EXAMPLE OF ILE ALATAU)

Aidana Kamalbekova, Victor Blagoveshchensky, Sandugash Ranova, Uldzhan Aldabergen

•

Institute of Geography and Water Security JSC, Almaty, Kazakhstan
aidana.kamalbekova@gmail.com
ingeo_2009@mail.ru
sandu2004@mail.ru
aldabergen_u@mail.ru

Abstracts

The article deals with the experience of using an unmanned aerial vehicle (DJI Matrice 300 RTK) and Agisoft Metashape software to obtain the characteristics of avalanches that descended in late March in the Shukur and Kotyrbulak tracts (Pioneer avalanche) in the Ile Alatau mountains. UAVs can perform observations in remote and dangerous areas, quickly reach the scene, and capture high-quality images and video. In Agisoft Metashape, data processing is performed to create digital elevation maps, 3D models and obtain various geometric data. The resulting data can be used to analyze and predict avalanche processes, as well as to develop measures to reduce the risk of such processes in the future.

Keywords: unmanned aerial vehicles, digital elevation model, orthophoto, 3D surface models, Agisoft Metashape, snow avalanches

I. Introduction

Avalanches are widespread in the mountainous regions of Kazakhstan, with hundreds of avalanches being recorded in the Ile Alatau. Since the middle of the last century, 95 people have died under avalanches in Kazakhstan and 80% of the incidents occurred in the Ile Alatau mountains. The use of unmanned aerial vehicles (UAVs) to study avalanches is a relatively new but very promising direction [1,2]. Drones nowadays are developing at an amazing speed, it is reasonable to use drones in almost all spheres of activity. Drones make it possible to carry out observations in remote and dangerous areas, as well as to obtain high-quality images and accurate data, which makes them a valuable tool for monitoring hazardous processes.

Unmanned aerial vehicles offer significant advantages for research [3]. Some of the major advantages include:

1. Safety: their use can greatly enhance the safety of researchers.
2. Efficiency: they can be brought to the scene quickly, allowing rapid damage assessment, assurance that the area is safe, and decisions to evacuate or secure the scene.
3. High accuracy: they can capture high quality images and video that can be used for analysis. This provides more accurate and detailed information than a ground based survey.
4. Low cost: their use can be more cost effective than using pilot-operated aircraft or ground-based means. This can reduce the cost of surveys and provide better access to data.
5. Large coverage: they can move quickly over large areas, allowing large areas to be studied quickly.

6. Automatic control: they can be controlled automatically, which reduces the need for a pilot, and may also allow operation in areas that are difficult to access or in poor weather conditions.

To obtain avalanche characteristics using a UAV, the following steps should be carried out:

1. Equipment preparation: for data collection, it is necessary to use a UAV with a camera capable of recording high-resolution images. In our study, we used a DJI Matrice 300 RTK drone. It is equipped with many sensors and features that allow it to perform different tasks, two cameras that allow it to capture high quality video and photos, a LiDAR sensor that allows it to create accurate 3D models of the terrain. To improve its positioning accuracy, the DJI Matrice 300 RTK uses the RTK (Real Time Kinematic) system, which provides positioning accuracy to within a centimeter. It also has the ability to utilize the PPK (Post Processing Kinematic) system, which allows for increased positioning accuracy with post flight processing.

2. Location selection: it is necessary to select a location where avalanches are observed.

3. UAV flight: after preparing the equipment and selecting the location, the UAV should be launched and fly over the study area. To obtain the most accurate data, it is recommended to fly at different altitudes and camera angles.

4. Data processing: after obtaining the photos it is necessary to process them using Agisoft Metashape program. The program can be used to create digital elevation maps, 3D surface models based on photographs, and various geometric data, including longitudinal profiles, digital elevation maps (DEM) and digital terrain models (DTM). In order to build a 3D model, a set of photographs including high-resolution images of objects must be taken. Once the set of photos is loaded into the program, Agisoft Metashape will align and merge the photos to create a 3D model of the object. Additional steps are required to produce a digital elevation map and digital terrain model. First, the program determines the position of each point on the object's surface and uses this data to create a point cloud. Then it creates DEM and DEM using the point cloud data. To obtain a longitudinal profile, it is necessary to select the line along which the profile is to be drawn. This can be done, for example, by selecting a line on a digital elevation map. The program then automatically builds the longitudinal profile by displaying the zone elevations along this line. Agisoft Metashape can also be used to analyze the size and shape of objects, obtain volumes and areas. The program can provide valuable information about the structure and geometry of the areas under study, as well as predict possible future hazards.

5. Data analysis: the obtained data can be used to analyze and predict avalanche processes, as well as to develop measures to reduce the risk of such processes in the future.

Using this method, we determined the parameters of avalanches that descended in late March 2022 in the Shukur and Kotirbulak tracts (Pioneer avalanche) in the Ile Alatau Range.

To determine the avalanche parameters, we used the method of differential aerial photography. Its essence consists in comparing two digital elevation models obtained by aerial photography: one digital elevation model is obtained immediately after avalanches, when the avalanche snowpack has not yet had time to melt; the other digital elevation model is obtained after full melting of the snowpack in summer.

By subtracting the second digital elevation model from the first, a digital avalanche snowpack model is obtained, which makes it possible to determine the avalanche volume. This method is one of the most accurate and reliable ways to determine the volume of avalanche snow slopes, as it allows taking into account the changes in the territory after the avalanche.

According to the survey results, the following parameters of the avalanche in Shukur were determined: avalanche stopping point - 2353 m, length - 140 m, average width - 29 m, area - 4117 m^2, average thickness - 2.4 m, maximum thickness - 6 m, volume - 9865 m^3.

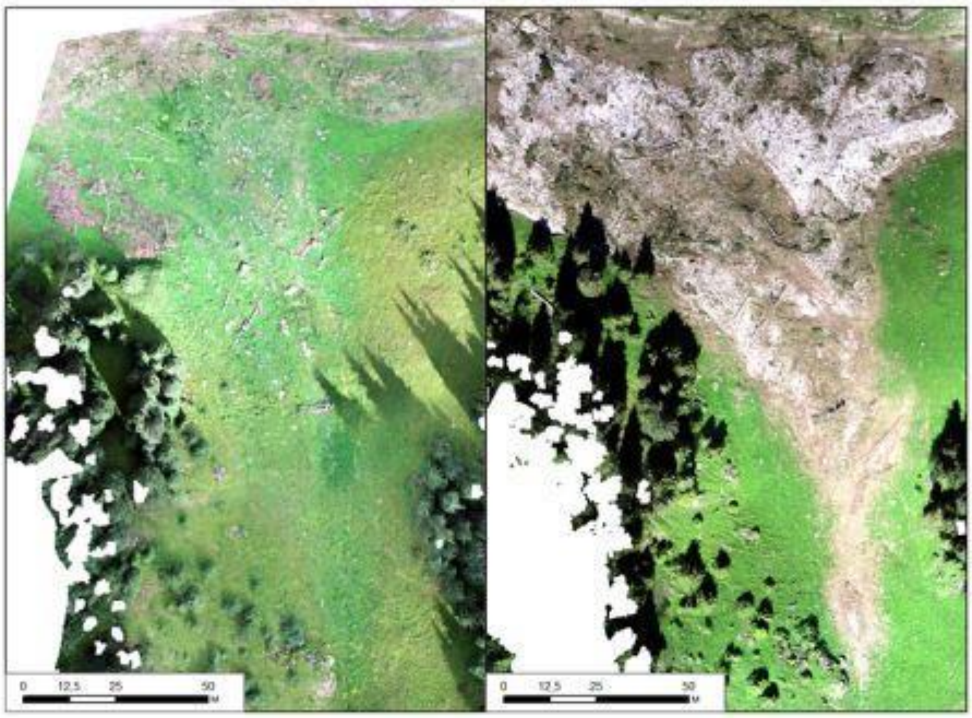

Fig. 1: *Orthophoto of the avalanche rollout area in Shukur with (right) and without (left) avalanche snowpack*

Fig. 2: *3D model of avalanche rollout area with avalanche snowpack*

Pioneer avalanche data: stop point - 1845 m, length - 265 m, average width - 32 m, area - 8480 m^2, average thickness - 3.6 m, maximum thickness - 7.2 m, volume - 30528 m^3.

In the 21st century, technology does not stand still. Older equipment is being replaced by digital and laser devices. The use of various new technologies is replacing traditional methods. Avalanche researchers, in order to accurately determine the limits of avalanche spread and avalanche volumes, use a very labor-intensive method in which the contours of the avalanche snowpack are measured with geodetic instruments and its thickness is measured with avalanche probes. The limit of avalanche thickness measured in this way is 3 meters. Only a small number of avalanches can be measured with this method. The remaining majority of avalanches are mapped visually, and their volumes are also estimated visually with a very large error [4, 5]. In this paper, we demonstrate how this problem can be solved by using aerial photography of avalanche stopping zones from unmanned aerial vehicles (UAVs).

Fig. 3: *Orthophotomaps of the area with and without avalanche snowpack near the "Pioneer" campground*

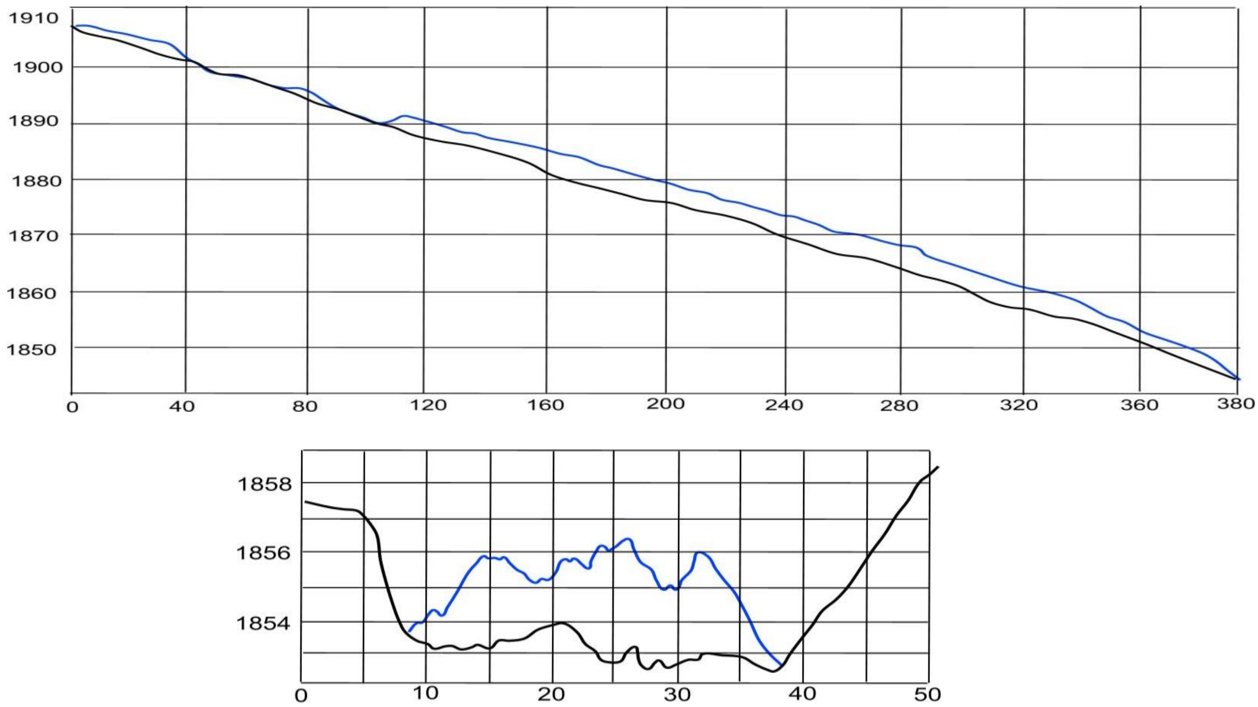

Fig. 4: *Longitudinal and transverse profiles of avalanche snowpack*

Acknowledgements. The article was written based on the results of research under the project "Development of a method for forecasting snow avalanches in Ile Alatau using artificial intelligence methods", funded by the Committee of Science of the MNVO RK (grant No. AP09260155).

References

[1] Low cost surveying using an unmanned aerial vehicle // ISPRS - International Archives of the Photogrammetry Remote Sensing and Spatial Information Sciences 40(1):311-315, August 2013, https://doi.org/10.5194/isprsarchives-XL-1-W2-311-2013.

[2] Yawar Hussain, Romy Schlögel, Agnese Innocenti, Omar Hamza, Roberto Iannucci, Salvatore Martino, Hans-Balder Havenith, Review on the Geophysical and UAV-Based Methods Applied to Landslides// Remote Sens. 2022, 14(18), 4564 https://doi.org/10.3390/rs14184564

[3] Use of unmanned aerial vehicles in monitoring application and management of natural hazards// Geomatics, Natural Hazards and Risk Volume 8, 2017 - Issue 1, pages 1-4 https://doi.org/10.1080/19475705.2017.1315619

[4] Ystykul K.A., Seredovich V.A. Investigation of snow avalanches using the technology of terrestrial laser scanning // Vestnik KazNU, Geographical Series. - №1 (40). - 2015. - C. 372-380. EDN: YWRNYL

[5] Ystykul K.A., Seredovich V.A., Baigurin J.D. Mapping of avalanche danger zones in the high-mountain recreational zone of Ile Alatau using laser scanning data // Interexpo Geo-Siberia. - 2016. - T. 1. - № 2. - C. 101-107. EDN: ROXVAD