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Remote sensing and UAV for assessing landforms changes at the proglacial area of Malij Azau Glacier (Mt Elbrus, Central Caucasus)

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Numerous studies report that the global climate change leads to the shrinkage of mountain glaciers that are highly sensitive to climate alterations. The variations in global temperatures have affected glacier regimes and parameters, specifically, area and volume. This hypothesis can be tested through cartographic and remote sensing monitoring of the glacial features and the evolution of landforms and deposits in proglacial areas. In the last decades, remote sensing has received increasing attention for assessing impacts derived from climate change. It enables comparison of landscape dynamics related to recent glacier retreat on a multitemporal scale and has potential for identifying geomorphological features and evaluating modifications.

In proglacial areas glacier retreat is accompanied by formation of lakes within glacier moraines. In the last fifty years active formation of proglacial lakes has been observed in Central Caucasus. The aim of this study is to assess the lake dynamics and the morphological evolution produced in a small catchment at the foot of the Malij Azau Glacier due to changes experienced by the glacier in the last decades. For this purpose aerial and satellite images of different years together with a Digital Surface Model (DSM) acquired during Unmanned Aerial Vehicle (UAV) field surveys at the southern slopes of Mt. Elbrus are compared. The topography of the study area was mapped on 14/15th of August 2017 by help of a DJI Phantom 3 quadrocopter with mounted digital camera (12 MP). A total of 3,329 UAV-borne images were processed to derive an orthophoto mosaic and a DSM of an area with 4 km^2 extent during a field campaign supported by IAEA INT5153 project. Average flying altitude was 100 m above ground of the start position. The flight path was configured to obtain an overlap of neighboring images of about 70–80%. For matching and creating the mosaic the overlapping images had to be aligned using common points on different images. The method Structure from Motion (SfM) was used to compile an orthorectified image mosaic (resolution 0.06 m) and a DSM (0.50 m resolution). Georeferencing has been done by merging on-board GPS-based positioning data of the UAV with ground control points surveyed with a DGPS. For delineating geomorphological features visual interpretation of the orthophotomosaic and topographic analysis of the DSM were combined. The results extracted from the satellite images and the DSM data show a great morphological evolution in the last decades and highlights that UAV's are fundamental tools for the quantification of spatial and temporal variation of glacial lakes, which could not be attempted through conventional mapping.