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Dynamics of the Mt. Elbrus glacial system

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The Caucasus is a high mountain region with the highest point reaching 5642 m for Mt. Elbrus covered by glaciers with total area of more than 100 km2. In this research we were focused on the recent changes of Mt. Elbrus glaciers as the result of changing climate. The materials of instrumental surveys of the Elbrus glaciers for the period of 120 years were accumulated so far. The previous works were based on direct comparison of the results of mapping despite the difference in conventional coordinate systems and heights used in different time periods. This was the reason for discrepancies in the interpretation of data on the state of the Elbrus glaciers obtained at different times and by different performers. In our study, all the available large-scale historical topographic maps (since 1887) as well as the remote sensing data (since the end of 1930th) were geoprocessed. To reconstruct changes in glaciers length and area we analyzed: historical large-scale topographic maps (1887; 1957); high-resolution aerial images (the end of 1930th; 1957; 1981; 1987; 1997); high-resolution satellite images (1971; 2007; 2015; 2017); phototheodolite surveys (since 1957, every 10 years). In 2017, for the first time we repeated stereophotogrammetric survey of the glaciers of the southern slope of Elbrus from the phototheodolite basis of the international geophysical year (1957–1958) using a panoramic camera set based on a widescreen digital camera (HASSELBLAD H3D-ll) with high resolution instead of the traditional phototheodolite. The aerial photography from the DJI Phantom 3 Advanced unmanned aerial vehicle was carried out in 2017 for the tongues of the Bolshoy and Maliy Azay glaciers. Based on the survey results, DEMs of the surfaces of glaciers and adjacent territories were compiled. Using a high-precision GNSS receiver, the coordinates of the base points and ground control points were determined, which made it possible to bring all the DEMs compiled from cartographic and digital survey materials of the study area to a single coordinate system and altitude. Comparison of multi-temporal DEM allowed us to obtain quantitative data on changes in the size of the Elbrus glaciation and to assess the accuracy of measurements in different ways. The values of the southern slope glacier's fronts retreat were determined. The obtained quantitative data on changes in the glaciation of Elbrus show that over a long time, its area decreased almost evenly. At the same time, there has been an increase in the rate of degradation of glaciers over the past 20 years (1997–2017), with a sharp increase over the past 10 years, starting in 2007. Lake sediments in the Caucasus potentially offer a detailed picture of environmental changes in the region. The lake sediment cores have been collected in two different lakes on the southern slope of Elbrus during the field work in 2017. An attempt was conducted to correlate data obtained in this research with the lake sediment cores processing results.