



## **Monitoring of a debris-covered and avalanche-fed glacier in the Eastern Italian Alps using ground-based SfM-MVS**

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The Montasio Occidentale glacier is a 0.07 km<sup>2</sup> wide, avalanche-fed glacier located at very low-altitude (1860-2050 m a.s.l.) in the Eastern Italian Alps. The glacier is still active and shows a detectable mass transfer from the accumulation area to the lower ablation area, which is covered by a thick debris mantle. Geometric changes and mass balance have been monitored starting in 2010, combining glaciological methods and high-resolution geodetic surveying with a terrestrial laser scanner (TLS). The TLS technique has proved to be very effective in determining the volume change of this glacier, but presents several limitations as high costs, high level of specialized training and low portability. On the other hand, the recent improvements in close-range photogrammetric techniques like the Structure from Motion (SfM), combined with dense image matching algorithms as Multi View Stereo (MVS), make them competitive for high quality 3D models production.

The purpose of this work was to apply ground-based photogrammetric surveys for the monitoring of the annual mass balance and surface processes of Montasio Occidentale glacier. A consumer-grade SLR camera and the SfM-MVS software PhotoScan were used to detect the changes in the surface topography of the glacier from 2012 to 2014. Different data acquisition settings were tested, in order to optimize the quality and the spatial coverage of the 3D glacier model. The accuracy of the image-based 3D models was estimated in stable areas outside the glacier, using the TLS 3D model as reference. A ground penetrating radar (GPR) survey was carried out in 2014, simultaneously to the photogrammetric survey, that was used to compare the snow height estimations obtained by photogrammetry with those obtained by geophysics.

The achieved results indicate that the resolution and accuracy of the 3D models generated by the SfM-MVS technique are comparable with those obtained from TLS surveys. Consequently, almost identical volumetric changes and mass balance estimates were obtained with the two methods in the Montasio Occidentale glacier test area.