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Rock glacier deformation using an Unmanned Aerial Vehicle (UAV) with RTK GNSS capability

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In high alpine geomorphological research, different technologies are increasingly used to describe and monitor mass movements such as rock glaciers. Among them, the combination of Unmanned Aerial Vehicle (UAV) systems and Structure from Motion (SfM) techniques is gaining continuous interest due to rapid technological developments. In this study, we test the capability of repeated UAV surveys to accurately survey rock glacier deformation in the Lac des Vaux area, Valais Alps. The studied landform is located on a typical anthropic alpine environment in the Swiss Alps, where ski facilities and alpine tracks are a commonplace. A DJI Phantom 4 RTK UAV was flown twice in September 2019 and September 2020 to cover an area of about 0.25 km^2 with nearly 1000 images each time. Differential corrections using a Virtual Reference Station (VRS) provided image geotags with centimetre-level accurate 3-D coordinates, thereby allowing dispensing with ground control. High-resolution orthomosaics and high-density point clouds are derived from the UAV-RTK surveys using a standard SfM processing workflow. The corresponding point clouds' accuracy was evaluated and adjusted based on stable terrain, reducing the 3-D alignment errors to a mean of 0.02 m. Elevation changes and surface kinematics in the rock glacier complex and its margins were quantified using point cloud operations and image correlation techniques. The results indicate that the landform has at least eight different lobes with mean velocities ranging between 0.1 and 1.3 m yr^{-1}. The high-resolution analysis also permitted identifying moving lobes without morphological expression and small thermokarst depressions on the ski slope structure that traverses the rock glacier's active zone. Without relying on ground control, our approach achieves horizontal and vertical accuracies nearly as good as monitoring techniques using more traditional differential GNSS devices.