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Documentation and post-event analysis of a large-scale snow avalanche with unmanned aerial system photogrammetry

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Snow avalanches pose a major threat to persons and material assets in mountainous regions around the globe. Timely surveying an avalanche event, for example to determine its extent, assessing deposition or release volumes, is essential for process understanding, hazard mapping, mitigation measure design or as input for avalanche simulation. So far, event documentation has mainly been carried out from the ground, e.g. by determining deposition depths on-site with terrestrial surveying techniques or entering the release area on foot to measure release depths. The availability of high-resolution remotely sensed imagery from manned airplanes or satellites is mostly restricted to catastrophic events, due to high costs. The proliferation of unmanned aerial system photogrammetry (UAS-P) has made an easy-to-use mapping tool readily available, which can be flexibly deployed to generate orthophotos and measure surface elevation with ground sampling distances (GSD) in the centimetre-range. In this contribution, we present the application of UAS-P to delivering high spatial resolution avalanche extent and deposition depth maps of a large-scale event. The surveyed avalanche occurred in the Pitz Valley in Western Austria near the village Hairlach on 22 January 2018. The avalanche spontaneously released at approximately 2,480 m a.s.l., split into several tracks and reached the valley bottom (1,280 m a.s.l.) where it overflowed an avalanche gallery protecting a road and deposited in the bed of the Pitze river below and reached an approximate, destructive size 3-4. The UAS-campaign was carried out on 30 January 2018. We employed a fixed-wing platform to map an area of approximately 1 km^2 covering the avalanche track and deposition zone. The UAS was equipped with an off-the-shelf Sony NEX-5 RGB camera (14 MP), fitted with a 16 mm prime lens. It collected 689 images from an altitude of 140 m above ground level. We processed the imagery in structure-from-motion photogrammetry software (Agisoft Photoscan, v1.4) to calculate an orthophoto (OP) and a digital surface model (DSM) with 0.05 and 0.2 m ground sampling distance, respectively. The extent of the avalanche was manually delineated from the OP; deposition depth of avalanche debris in the track and runout were calculated from the UAS-DSM and pre-event airborne laser scanning data. In total approximately 50,000 m^3 of avalanche debris were documented over an area of 2.2 hectares. Peak deposition depth reached 9.1 m in the avalanche terminus near the river, mean deposition depth was 2.6 m over the entire area. These results were used as input for model runs with the numerical avalanche simulation software SamosAT, aimed at back-calculating peak avalanche pressures and velocities. The observed data is in particular useful to evaluate the design and effectiveness of avalanche mitigation measures in the avalanche track, such as breaking mounds or deflecting dams.