



## **Multi-temporal monitoring of crack formation on a mountain col with low-cost unmanned aerial systems – a case study in Austria**

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In the Tuxer Alps of Western Austria, crack formation was observed on a col at approximately 2,500 m a.s.l., in close proximity to a highly frequented hiking trail. On an area of 0.2 ha, three several meter deep cracks were identified. Here we present the results of a 3-year monitoring of this area with low-cost, unmanned aerial systems (UAS) and photogrammetric techniques. In 2013 and 2014, a custom-built fixed-wing UAS (Multiplex Mentor, wingspan 1.6 m, gross take-off weight 2.5 kg), equipped with a Sony NEX5 (16 mm prime lens, 14 MP sensor resolution) was used to map the study site. In 2015 we employed a helicopter (Thundertiger Raptor, 0.55 m blade length, gross take-off weight 2.8 kg), fitted with a GoPro2 (60° prime lens, 5 MP sensor resolution). In all three cases we recorded 1,200-2,000 images in 10-30 minutes. To georeference the images, 8-10 ground control points (GCP) were placed at the study site and measured with a Trimble GeoXT GPS device (expected accuracy 0.15 m, precision 0.3 m). Using AgiSoft's PhotoScan (v.1.1.6), Orthophotos (OP) and digital surface models (DSM) were calculated with 5 and 20 cm ground sampling distance, respectively. The visual interpretation of the OPs gave some indication, that the size of the cracks was increasing by 0.1-0.5 m (A-axis) or 0.2-0.8 m<sup>2</sup> per year. An interpretation of the DSMs was inconclusive with regard to the depth of the cracks due to shadows in the imagery and vertical or overhanging sidewalls of the cracks. Additionally the accuracy of the GCP-measurements was found to lie below the rate of change of the cracks, thus not permitting a direct calculation of difference DSM. From an operational point-of-view, the study site proved very challenging because of its exposed, high-alpine location, with high wind speeds, gusts and poor visibility hampering the UAS-missions. The monitoring campaign will continue in 2016, where the collection of additional ground-based reference data is planned (e.g. terrestrial photogrammetry, manual measurements, terrestrial laser scanning).