THE VALALANCHE PROJECT: PUTTING RECENT PROGRESS IN SNOW AVALANCHE MAPPING INTO PRACTICE

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ABSTRACT: Avalanche mitigation as well as decision making depends on the knowledge of historical avalanche records. However, the accurate mapping of avalanches as well as the mapping of the respective release zones remains a crucial, yet often overlooked task. The Valalanche project aims to facilitate a high-quality avalanche mapping by the means of novel technologies. The structure of the project is threefold: (i) a smartphone application for the rapid documentation of avalanches in the terrain. (ii) Fixed-wing and copter-style drones, for the mapping of avalanche deposits and the surveying of release zones. (iii) A web-GIS platform for automated processing, visualization and analysis of the data in 2D and 3D. The basic idea is to reduce the technical expert knowledge often required in the application of novel technologies to a minimum by a specifically tailored software architecture and IT solution. First data collected in Goms and Mattertal region in canton Valais, Switzerland during the winter 2017/18 showed the feasibility of the project. Distances, heights and volumes for deposition zones and release areas were quantified with sufficient accuracy. Further applications include the surveying of glide snow activity and the monitoring of blasting results. Feedback received from the regional warning service and governmental responsibilities were highly positive, proving the added value of this concept for decision making and planning instances.

KEYWORDS: Avalanche mapping, digital documentation systems, operational tools, IT solutions, remote sensing, UAV, smartphone.

1. INTRODUCTION

Avalanche mitigation as well as decision making highly depends on the knowledge of historical avalanche records. The planning of protective measures is mostly based on historical events. Modern avalanche simulation programs depend on quantitative information on release areas and run out distances for calibration. Decision makers profit from the knowledge of the avalanche history, and they rely on a sound documentation of recent events to assess the avalanche activity. The accurate documentation of avalanches is therefore a crucial, yet often overlooked task.

In the recent years, substantial progress has been made by scientists regarding the application of modern technologies in snow and avalanche science. Drones e.g. allow for a precise and quantitative mapping of avalanches (Bühler et al., 2006). However, these technologies still require a certain level of expert knowledge, especially with regard to usability and data evaluation, which limits their scope of application to date. The Valalanche project aims to overcome these issues by tools to increase the user friendliness such as pre-planned flight path, a platform for automated data processing and by offering training and support for users in the warning services. The project therefore attempts to put the advances in snow science into practice, i.e. to allow these novel technologies to be applied in an operational context. This will ultimately lead to a larger and more precise avalanche data base for planning instances and decision makers will profit from a better assessment of avalanche activity and the possibility to survey release areas.

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2. CONCEPT

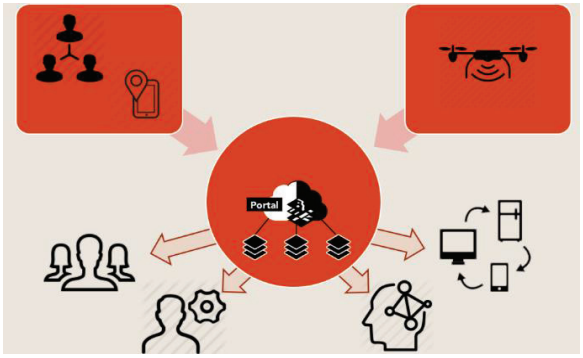

Figure 1: The Valalanche concept.

The structure of the project is threefold (Figure 1): (i) a smartphone application for the rapid documentation of avalanches in the terrain. (ii) Fixed-

wing and copter-style drones, for the mapping of avalanche deposits and the surveying of release zones. (iii) A web-GIS platform for automated processing, visualization and analysis of the data in 2D and 3D.

2.1 Avalapp

The smartphone App Avalapp is designed for avalanche monitoring “on the go”. The photographic documentation, which is the most important feature, is completed by information on avalanche type, size, consistency, etc. GPS coordinates as well as basic geodata for location and field of view are stored automatically. In addition, basic drawing features for outlines, release zones and damages are available. The App will be available winter 2018 for the warning service of the Goms region in Valais, Switzerland and a test-user group.

2.2 Avalmap

Avalmap contains copter-style as well as Fixed-wing UAV-systems. UAV-systems have become a state-of-the-art technology, not only in snow science. However, their application in an operational context is still limited as a high level of technical expert knowledge with respect to data processing and evaluation is required. The idea of the Valalanche project is to overcome these issues by an automated processing chain and pre-planned flight plans, thus enabling also non-expert users to apply and benefit from UAV-systems.

In the project, commercially available DJI Mavic drones are used for the fast and easy mapping of smaller features from easy access sites. Run out distances can be assessed quickly, and topographic obstacles overflown to get a better field of view. Nevertheless, these drones offer enough accuracy e.g. to calculate relative deposition volumes and release heights.

Fixed-wing drones are used for the mapping of larger features at remote sites. Pre-planned flight tracks can be designed for the avalanche couloirs and release zones of interests. Fixed-wing drones are as well suited for the surveying of release zones, protection measures and blasting results. Equipped with real-time kinematic (RTK) technology, these drones offer georeferenced and quantitative information without the use of ground control points (GCPs). An existing Fixed-wing solution will be modified to best suit the needs of the Valalanche project.

2.3 Avalyse

The Avalyse platform offers an automated processing chain to generate Orthophotos and DSMs/DEMs form the data collected by the drones. The platform further serves as data archive and guarantees easy access. In addition, visualization and analysis features are included which allow operational instances to rapidly access the required information without time consuming data processing. A Beta-version of the Avalyse platform is already available. (Figure 2).

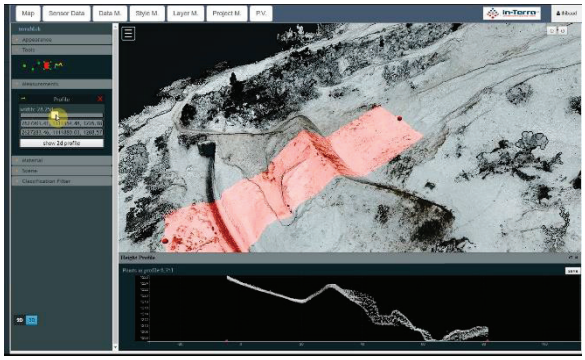

Figure 2: Analysis of avalanche debris using the Avalyse-Beta version.

3. RESULTS WINTER 2017/2018

During winter 2017/2018, DJI Mavic drones were used in the Goms region and in Mattertal, both canton Valais, Switzerland. In addition, three flights using a commercially available Fixed-wing (sensefly eBee) were performed on 31.01.2018 in the Bellwald ski area in the Goms region.

3.1 Blattbach avalanche path

On 19.01.2018, the Blattbach avalanche in Mattertal covered more than 100 m railroad track of the Matterhorn Gotthard Bahn with deposition heights up to 8 m (Figure 3). The avalanche was mapped using the DJI Mavic system, giving a detailed overview of the run-out zone and allowing to calculated distances and relative heights and volumes with sufficient accuracy.

3.2 Bellwald ski area

The results of the flights in the Bellwald ski area gave a detailed picture of the (wet and glide snow) avalanche activity (Figure 4). Other features of interest for the warning service were mapped as well: the amount of snow on protection measures, e.g. to asses if avalanche barriers are still effective (Figure 5), blasting results giving insights into snowpack stability and release zones with, in this case, a Sahara dust layer as gliding surface (Figure 6).

The potential size for wet snow avalanches could be calculated from the relative depth of glide cracks (Figure 7). The volume in case of release was estimated to be 25000 m^3, which would be sufficient to reach the valley bottom regarding the steep and channeled avalanche track below.

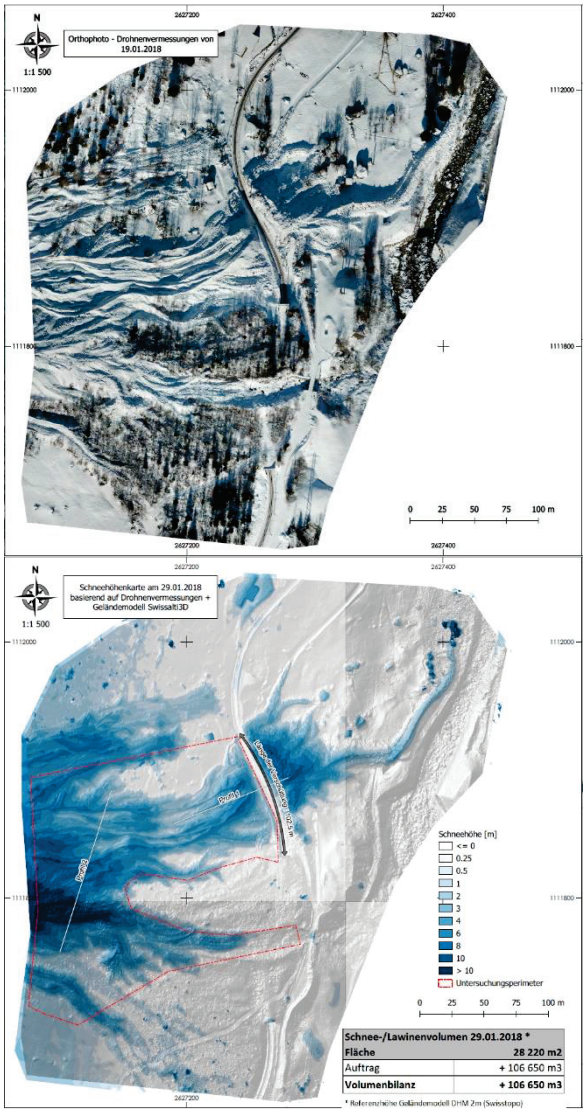

Figure 3: Orthophoto of the Blattbach avalanche (top) and deposition volumes (below).

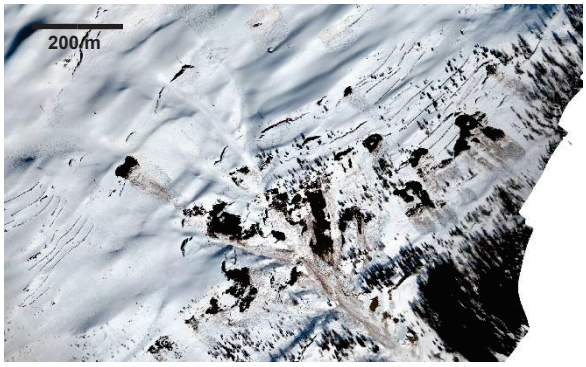

Figure 4: Glide and wet snow activity in the release area of Schwarze Brunne avalanche path close to the Bellwald ski area.

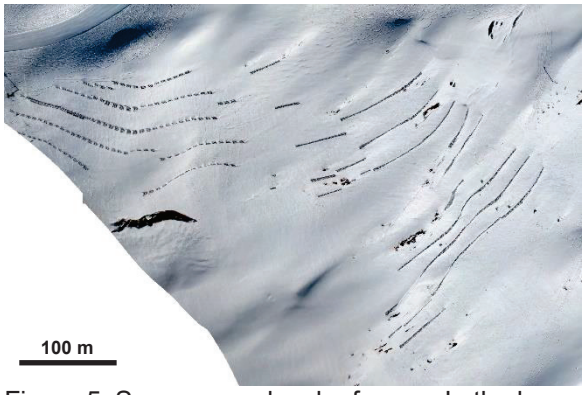

Figure 5: Snow on avalanche fences. In the lower right, some fences are already buried, providing no more protection in the case of an additional snowfall.

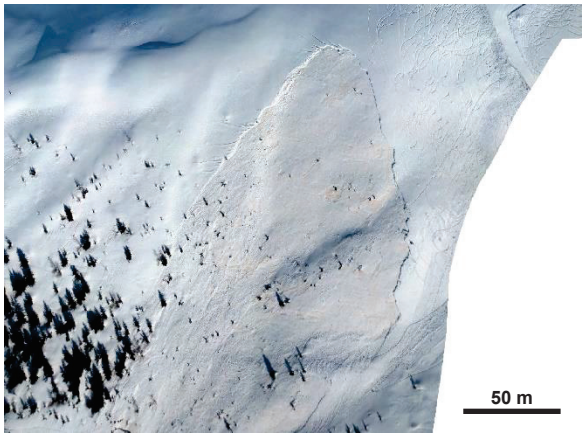

Figure 6: Release zone with Sahara dust layer as gliding surface.

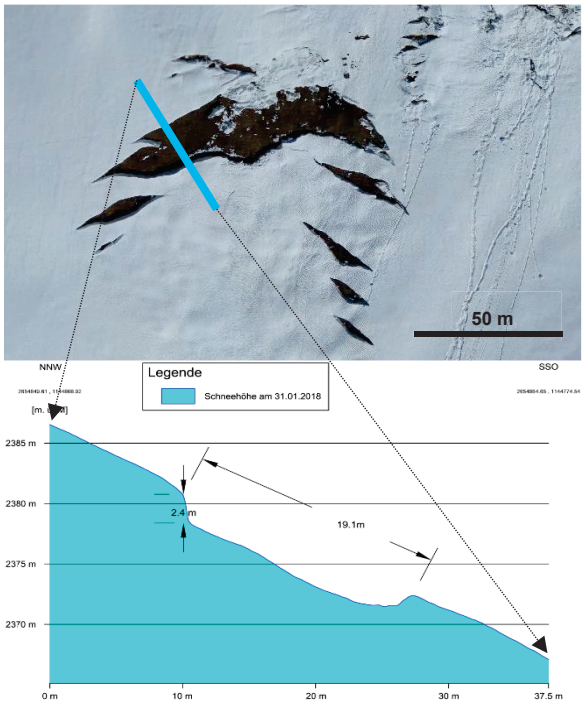

Figure 7: Glide snow crack with profile line (top, blue) and profile (bottom) showing ca. 2.5 m of potential release height.

4. DISCUSSION AND CHALLENGES

The project is designed to support regional warning services and planning instances. Using modern technologies, avalanche mapping as well as release zone surveying is facilitated. However, technical limitations with respect to harsh meteorological conditions during UAV-flights, accurate georectification due to low GPS-signal in steep mountainous terrain (for the non RTK-systems), or the computational power for the automated processing chain cannot be avoided. Drone flight legislation will be tightened in the coming years in Switzerland, potentially complicating the use of UAVs and making additional equipment such as trackers necessary.

Nevertheless, feedback from the Goms warning service and authorities was highly positive. Drone handling was described as easy and intuitive and results as highly valuable and attractive for their visual nature. It should be mentioned that in an operational context a scientific accuracy is not particularly necessary: meters are sufficient for runout mapping, and decimeters for the deposition heights. For release zones a higher accuracy is desirable, which is where the RTK-systems will be applied. However, the benefit of these technologies in an operational context outweighs the loss of accuracy, i.e. better having a mid-precise orthophoto than no orthophoto.

Concerning Avalapp, Tremper and Diegel (2014) reported on the Utah Avalanche Center smartphone App, that also observations submitted by non-professionals had surprisingly high quality. Vastly more non-professionals than professionals are in the backcountry and they seem to be willing to go to riskier places than professionals. Of 527 backcountry avalanches reported to the Utah Avalanche Center public database in 2013/14, 72% came from non-professionals and 90% included photos. Avalapp is thought to go public as well.

5. OUTLOOK

The winter 2018/2019 will serve as test case for the whole Valalanche product chain. The Avalapp will be introduced, DJI Mavic Drones will be handed out to the warning service, a prototype of the fixed-wing system will be in use and the Beta-version of the Avalyse platform will be launched. Pre-planned flight tracks and the automatic processing chain will be tested and further developed. In addition, more data form release zones will be collected to test and improve their surveying and monitoring. All these steps will be taken in close collaboration with the regional warning service and the respective authorities.

The platform could be connected to existing IT infrastructure including avalanche towers, detections and warning systems or safety concepts, in order to provide an integral snow safety management tool.

The linkage of Avalapp with social media services to gather more observations following Tremper and Diegel (2014) could be realized as well.

The project will become operational in 2020. After that, several elements could be applied to other natural hazards like rock falls and landslides.

ACKNOWLEDGEMENTS

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