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The potential of UAV-data for surveying sediment dynamics - A case study in the Gesäuse National Park

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Keywords

Sediment dynamics, Gesäuse National Park, UAV, SfM-MVS, TLS, DEM of Difference

Summary

This contribution summarizes the main aspects of a master thesis that dealt with the potential of UAV-data for surveying sediment dynamics. The thesis was submitted at the Department of Geography and Regional Science Graz and was supervised by Wolfgang Sulzer and Oliver Sass.

Unmanned aerial vehicles (UAV) in combination with relatively new photogrammetric processing techniques, namely Structure from Motion Multi View Stereo (SfM-MVS), have a huge potential for environmental monitoring and the acquisition of high resolution geodata not only in fluvial environments. This has been demonstrated by several studies (e.g. WHITEHEAD et al. 2014; PAJARES 2015; SMITH et al. 2016). However, the analysis and especially the validation of this datasets can be challenging.

The master thesis tries to evaluate the usability of UAV data for surveying sediment dynamics based on a case study in a fluvial environment. For that purpose, a test area (Langgriesgraben) in the Gesäuse National Park was selected. The Langgriesgraben is a side channel of the Johnsbach river. Due to the surrounding brittle dolomite bedrock, the climatic conditions and the relief energy, a huge amount of sediment is available in the catchment. The torrent has only episodic discharge, but a lot of sediment is transported during flood events. Flood events typically occur after snowmelt in spring and during heavy precipitation events in summer. As many areas in the Gesäuse the study site can be described as an area with very high geomorphic activity.

For the study, in a first step, high resolution UAV images (mean ground sampling distance 2-3 cm) of the river bed had to be acquired. In total three UAV missions (31.07.2015/ 22.09.2015/ 22.10.2015) were carried out. The aerial images were taken with a consumer grade camera mounted on a hexacopter. The flying height in the missions was between 60-100 m above ground. The planned image overlap was 80% along track and 60% across track.

The acquired aerial images were used to derive digital point clouds, digital terrain models and orthophotos of the channel using the SfM-MVS method. Processing was performed with the photogrammetric software package Agisoft Photoscan Professional. The georeferencing of the datasets was performed indirectly via ground control points. A network of ground control points was established for that purpose. All ground control points were measured with a GNSS and were marked in the field during the UAV campaign. From the point clouds, digital terrain models with different spatial resolutions (5 cm 10 cm and 20 cm) and an orthophoto mosaic was computed.

In the following step, the derived products were validated. The height accuracy from the digital terrain models and the planar accuracy of the orthophotos were estimated from GNSS measured check points. The achieved accuracy (e.g. height accuracy DTM: 4-7cm RMSE) is in the expectable accuracy range found in literature (e.g. SMITH et al. 2016). Hillshades of the digital terrain models were computed for further visual data inspection. Shadow areas in the aerial images and areas covered by dense vegetation were leading to areas with higher uncertainty in the derived models. In future UAV missions, more emphasis should be put on the lighting conditions during image capture. Most of the area of interest in this study is free of vegetation. In this case, higher uncertainties or missing ground information related to dense vegetation cover is not a big issue.

For one timestep the UAV datasets were also compared with almost simultaneously acquired TLS data. The comparison of the datasets was performed with three different methods: (a) cloud to cloud comparison (b) cloud to mesh comparison (c) DoD comparison. For the comparison two test plots in the channel and one test plot on a slope close to the main channel were selected. The comparison was performed with CloudCompare and ArcGIS. The deviation between UAV and TLS is 6-12cm (95th percentile of the deviation) depending on the method used for the comparison and test site.

Through the UAV terrain models from different timesteps it was possible to calculate surface changes in the channel. The DoD (DEM of Difference) method with a minLOD (minimum level of detection) was used to accomplish that task. This is a widely used method in fluvial geomorphology (e.g. BRASINGTON et al. 2003). Based on the calculated minLOD (14cm) a significant change could only be estimated at 12% of the total area. In the observed period (53d) the deposition (295m³) predominates the erosion (163m³) of sediment. This is consistent with the TLS measurements by (RASCHER & SASS 2017). The results show that the used method SfM-MVS in combination with an UAV can detect bigger rates of change. Smaller changes, however, are not detectable due to the reached accuracy.

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