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Exploring topographic methods for monitoring morphological changes in mountain channels of different size and slope

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High resolution digital elevation models (DEM) can easily be obtained using either laser scanning technology or photogrammetry with structure from motion (SFM). The scale, resolution, and accuracy can vary according to how the data is acquired, such as by helicopter, drone, or extendable pole. In the Autonomous Province of Bozen-Bolzano (Northern Italy), we had the opportunity to compare several of these techniques at different scales in mountain streams ranging from low-gradient braided rivers to steep debris flow channels. The main objective is to develop protocols for efficient monitoring of morphologic changes in different parts of the river systems.

For SFM methods, we used the software "Photoscan Professional" (Agisoft) to generate densified point clouds. Both artificial and natural targets were used to georeference them. In some cases, targets were not even necessary and point clouds could be aligned with older point clouds by using the iterative closest point algorithm in the freeware "CloudCompare".

At the Mareit/Mareta River, a restored braided river, an airborne laser scan survey (2011) was compared to a SFM DEM derived from a helicopter photo survey (2014) carried out (by the Autonomous Province of Bolzano) at approximately 100 m above ground. Photogrammetry point clouds had an alignment error of 1.5 cm and had three times more data coverage than laser scanning. Indeed, the large spacing and clustering of 2011 ALS swaths led to areas of no data when a 10-cm grid is developed.

In the Gadria basin, a debris flow monitoring catchment, we used a sediment retention basin to compare debris flow volumes resulting from i) a drone (by the "Mavtech" company) survey at 10 m above ground (with GoPro camera), ii) a 5-m pole-mounted camera (with Canon EOS 700D) and iii) a 3-m pole-mounted camera (with GoPro Hero Silver3+) to a iv) TLS survey. As the drone had limited load capacity (especially at high elevations) we used the lightweight GoPro Hero 3+, but due to the its low image quality and low survey elevations, more reference points were needed which became impractical. In contrast, the TLS survey was heavily influenced by the shadowing of the rough surfaces.

Even though the pole-mounted camera is of lower technology, it has proven to be accurate (< 2cm RMSE) with better data coverage than the TLS due to the aerial perspective. Furthermore, the pole-mounted camera is the most field efficient due to the dependency of one person (little training required), little weather limitations, and a five times faster data acquisition than TLS surveys. A shorter pole with a GoPro camera allows faster and easier surveys but with the drawback of less precision and more noise. We easily obtained up to 6 DEMs of difference (DoD)within one year in active channel reaches and gullies in the Gadria catchment. This allowed to capture morphologic changes after important debris flow events, bedload transport, and bank erosion. DoDs also allowed us to monitor damages of structures due to erosional and depositional processes on alluvial fans. Our study highlights the importance of the bird′s eye view which can be easily obtained by low cost SFM photogrammetry.