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Hydrologic validation of a structure-from-motion DEM derived from low-altitude UAV imagery

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The increasing ease of use of current Unmanned Aerial Vehicles (UAVs) and 3D image processing software has spurred the number of applications relying on high-resolution topographic datasets. Of particular significance in this field is "structure from motion" (SfM), a photogrammetric technique used to generate low-cost digital elevation models (DEMs) for erosion budgeting, measuring of glaciers/lava-flows, archaeological applications and others. It was originally designed to generate 3D-models of buildings, based on unordered collections of images and has become increasingly common in geoscience applications during the last few years. Several studies on the accuracy of this technique already exist, in which the SfM data is mostly compared with Lidar-generated terrain data. The results are mainly positive, indicating that the technique is suitable for such applications.

This work aims at validating very high resolution SfM DEMs with a different approach: Not the original elevation data is validated, but data on terrain-related hydrological and geomorphometric parameters derived from the DEM. The study site chosen for this analysis is an abandoned agricultural field near the city of Taroudant, in the semi-arid southern part of Morocco. The site is characterized by aggressive rill and gully erosion and is – apart from sparsely scattered shrub cover – mainly featureless. An area of 5.7 ha, equipped with 30 high-precision ground control points (GCPs), was covered with an unmanned aerial vehicle (UAV) in two different heights (85 and 170 m). A selection of 160 images was used to generate several high-resolution DEMs (2 and 5 cm resolution) of the area using the fully automated SfM software AGISOFT Photoscan. For comparison purposes, a conventional photogrammetry-based workflow using the Leica Photogrammetry Suite was used to generate a DEM with a resolution of 5 cm (LPS DEM).

The evaluation is done by comparison of the SfM DEM with the derived orthoimages and the LPS DEM. Parameters evaluated include the flow accumulation, the extracted thalweg networks, slope and exposition. Thus, the question asked is not "Is the height at this specific point accurate compared to a true reference height?", but rather "Does the surface runoff modelled from this DEM behave in the same way as it does in reality?". This means that the DEM will be validated on a functional basis, examining the accuracy of hydrological connectivity and networks. The results of this work may help in the establishment of the SfM technique in geoscience applications, and give an idea of the hydrologic accuracy and reliability of such DEMs.