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Deformation analysis of a sinkhole in Thuringia using multi-temporal multi-view stereo 3D reconstruction data

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Sinkholes are a serious threat on life, personal property and infrastructure in large parts of Thuringia. Over 9000 sinkholes have been documented by the Geological Survey of Thuringia, which are caused by collapsing hollows which formed due to solution processes within the local bedrock material. However, little is known about surface processes and their dynamics at the flanks of the sinkhole once the sinkhole has shaped. These processes are of high interest as they might lead to dangerous situations at or within the vicinity of the sinkhole. Our objective was the analysis of these deformations over time in 3D by applying terrestrial photogrammetry with a simple DSLR camera.

Within this study, we performed an analysis of deformations within a sinkhole close to Bad Frankenhausen (Thuringia) using terrestrial photogrammetry and multi-view stereo 3D reconstruction to obtain a 3D point cloud describing the morphology of the sinkhole. This was performed for multiple data collection campaigns over a 6-month period. The photos of the sinkhole were taken with a Nikon D3000 SLR Camera. For the comparison of the point clouds the Multiscale Model to Model Comparison (M3C2) plugin of the software CloudCompare was used. It allows to apply advanced methods of point cloud difference calculation which considers the co-registration error between two point clouds for assessing the significance of the calculated difference (given in meters). Three Styrofoam cuboids of known dimensions (16 cm wide/29 cm high/11.5 cm deep) were placed within the sinkhole to test the accuracy of the point cloud difference calculation. The multi-view stereo 3D reconstruction was performed with Agisoft Photoscan.

Preliminary analysis indicates that about 26% of the sinkhole showed changes exceeding the co-registration error of the point clouds. The areas of change can mainly be detected on the flanks of the sinkhole and on an earth pillar that formed in the center of the sinkhole. These changes describe toppling (positive change of a few centimeters at the earth pillar) and a few erosion processes along the flanks (negative change of a few centimeters) compared to the first date of data acquisition. Additionally, the Styrofoam cuboids have successfully been detected with an observed depth change of 10 cm. However, the limitations of this approach related to the co-registration of the point clouds and data acquisition (windy conditions) have to be analyzed in more detail.