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Close range photogrammetry in soil erosion monitoring: Mass loss comparison between runoff plots and high resolution DEMs

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Soil erosion is a major environmental problem and can lead to severe negative impacts on terrestrial ecosystems. When raindrops hit a bare soil surface, the applied kinetic energy successively detaches soil particles. This rainsplash effect marks the initial stage of soil erosion, which can result in serious sediment losses with beginning surface runoff. Mini-runoff plots are often used to monitor soil erosion rates in comparative field experiments. However, this method is time-consuming, the sampling of detached soil is difficult and the accuracy heavily depends on thorough maintenance and control of the measurement setup.

To optimize the acquisition of soil erosion data from splash and interrill processes, a digital method using close range photogrammetry was tested in 2015. Therefore, a photogrammetric workflow was applied to process high resolution digital elevation models (DEMs) from overlapping stereo-images. By calculating the differences between multi-temporal DEMs with a sub-millimetre resolution, the volume of detached sediment was assessed. We performed rainfall simulations with a single nozzle rainfall simulator and a light weight tent. Micro-scale runoff plots (ROPs, 0.4 m x 0.4 m) were used with two different treatments, namely a Hortic Anthrosol and sand (grain size 0.10-0.45 mm). Five repetitions of rainfall-exposure with an intensity of 60 mm h-1 were performed and each repetition divided into three intervals (0-15 min, 15-30 min and 30-60 min). Before the first and every following interval, a block of 25 stereo-images was acquired with a single lens reflex camera system and processed in Agisoft PhotoScan for DEM-generation. After every interval, the discharged sediment was dried and weighed in order to derive the ground-truth validation data for comparison.

Results show that ROPs with the sand treatment generally showed a larger volume of detached sediment than the garden soil treatment. As sediment discharge increased, the modelled and measured volumes converged, partly yielding estimations of good accuracy for sediment discharge (mean 14.9 % difference between modelled and measured discharge). However, the accuracy for the garden soil treatment was lower and the calculated volume of detached sediment was generally much larger than the in situ measurement (mean 397 %). Nevertheless, higher volumes of discharge and thus greater elevation differences in the soil surface can be modelled accurately using photogrammetric methods, thus the approach should be pursued in the future. We assume, that inaccuracies of DEMs caused by inconstant light conditions, shiny features, software and camera issues as well as shadowing due to complex soil surface result in overestimations of small sediment discharges in the comparison of multi-temporal DEMs. Therefore, the procedure of image acquisition should be refined by using artificial illumination with LED-panels to grant constant conditions. Multiple calibrated cameras with a higher resolution and triggered simultaneously, could further increase the accuracy of DEMs.