

Photogrammetric technique-based quantitative measuring of gravity erosion on steep slopes in laboratory: Accuracy and application

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Abstract: Gravity erosion, is triggered by gravitational force and defined as the erosion and transportation processes of soil mass under its own weight. Gravity erosion, a dominant erosion type on steep hilly slopes, is widely located in gully head, gully side wall or river valley. Gravity erosion usually occurs within seconds in combination with hydraulic erosion, thus posing a great challenge to site-specific real-time measurement of gravity erosion. Compared with hydraulic erosion, the research of gravity erosion has been in a weak state because of its mechanism complexity and limited measuring methods. Quantitative measuring of gravity erosion is very important for a better understanding of soil mass failure occurrence and prediction. At present, soil erosion models (such as USLE, CSLE, and WEPP) only consider soil loss under hydraulic force, while the sediment yield produced by gravity erosion is usually indirectly analyzed through relationship between runoff and sediment or determined through the difference between the amount of total erosion and hydraulic erosion. Despite the establishment of soil erosion models involving the influence of gravity erosion by some researchers, those models are empirical equations of soil loss. The study of gravity erosion models requires a large number of direct observational data sets, most previous studies of gravity erosion are qualitative description rather than quantitative analysis, which also limits the establishment of gravity erosion models. Quantitative measuring of gravity erosion contributes to a better understanding of soil mass failure occurrence and prediction. However, the measurement of gravity erosion requires continuous monitoring of the objective terrain, due to its occurrence usually within seconds and combination with hydraulic erosion. The photogrammetric technique can quickly obtain terrain data and provide a new idea for measuring gravity erosion. Based on a continuous high overlapping image acquisition equipment, Structure-from-Motion-Multil-View-Stereo (SfM-MVS) integrated workflow, and volume calculation, a new working methodology was established for measuring gravity erosion on steep granitic slopes in the laboratory. The results showed a good match between the digital point clouds derived from SfM-MVS integrated workflow and terrestrial laser scanning (TLS), achieving millimeter-scale accuracy. The mean distance between the point clouds derived from TLS and SfM-MVS is 1.13 mm, with a standard deviation of 0.93 mm. The relative errors among the volumes calculated by SfM-MVS and TLS or the conventional oven-drying method were all within 10%, with a maximum error of 9.3% and a minimum error of 0.2%. A total of 213 gravitational erosion events were measured in the laboratory by using the SfM-MVS method, further confirming its feasibility.