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# From experimental plots to experimental landscapes: using SfM-MVS to monitor sub-humid badlands

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The high erosion rates exhibited by badlands have made them a common testing ground for geomorphological concepts and hypotheses. In the last decade advances in surveying technology have opened up the possibility of representing topography and monitoring surface changes over experimental plots in high resolution. Yet the representativeness of these small plots is limited. With 'Structure-from-Motion' (SfM) and 'Multi-View Stereo' (MVS) techniques now becoming part of the geomorphologist's toolkit, there is potential to expand further the scale at which we characterise topography and monitor geomorphic change morphometrically. Moving beyond previous plot-scale work using Terrestrial Laser Scanning (TLS) surveys, this paper validates robustly a number of SfM-MVS surveys against total station and extensive TLS data at three nested scales: plots (<30 m2) within a small catchment (4710 m2) within an eroding marl badland landscape ( 1 km2) in the Upper River Cinca catchment. SfM surveys from a number of platforms are evaluated based on: (i) representation of topography; (ii) observed surface roughness; (iii) change-detection capabilities at an annual scale. Oblique ground-based images can provide a high-quality surface at the plot scale, but become unreliable over larger areas of complex terrain. Degradation of surface quality with range is observed clearly for SfM models derived from aerial imagery and agrees with existing validation studies. Synthesis of results from many existing SfM validation studies yields an overview of the capabilities of the method in the geosciences. Sub-centimetre errors are achievable at 10 m range as might be provided by a camera inspection pole. For soil erosion monitoring in badlands, SfM can provide comparable data to TLS only from small survey ranges ( 5 m). Errors increase approximately linearly with survey range and ratios of RMSE : survey range of 1:563 are observed. Despite these errors, landscape-scale DEMs can be derived rapidly and at minimal expense and are likely to have a considerable impact on the future trajectory of geomorphology.