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Monitoring Topographic Change In Highly Erodible Landscapes By Means Of Terrestrial Laser Scanning

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Recent developments in survey instrumentation yield the opportunity to build high-resolution topographic models at the resolution of grain-scale upwards. Terrestrial Laser Scanners (TLS) are capable of acquiring unprecedented volumes of survey-grade observations over ranges 10^{-2} – 10^{3} m at 10^{-3} m accuracy. In this paper we present the topographic change of an experimental badland (90 m^2, Isabena Catchment, Pre-Pyrenees) after a series of rainfall events. Multi-temporal topographic models of the experimental site were obtained by means of TLS. Additionally, (i) the rainfall between each topographic survey was measured, (ii) the export of sediment from the experimental badland was monitored by means of a pit trap installed at the outlet, (iii) water samples were obtained when runoff was generated, and (iv) air temperature was monitored continuously. A total of 7 topographic surveys were obtained between 2009 and 2010. The first scan was obtained in summer 2009 as a reference, while the remaining six were surveyed regularly after rainfall events occurred between September and December 2010. The models were composed of between 1 and 7 million of survey observations. ToPCAT, an open source algorithm (will be available soon) designed to analyse large 3d point clouds, was applied to the TLS data sets. ToPCAT allows unifying point densities, creating multi-resolution gridded terrain products, and calculate statistical measures of the point clouds that, in turn, are used as a proxy of roughness. The results indicate as the maximum rainfall event was registered in September (22.3 mm). A total of 368 mm of rainfall were recorded between September-December 2010. Between the 25% and 83% of the events generated runoff. Suspended sediment concentrations oscillated between 14 and 96 g l^{-1}, while the maximum volume of sediment retained in the trap was of 59 kg. An event-based erosion rate of < 1 cm was obtained by comparing the topographic models between surveys, while the long term (16 months) erosion rate was estimated between 3 and 4 cm (yielding an annual erosion of 3cm yr^{-1} for the whole experimental badland by comparing September and December models). Preliminary analyses identify rainfall intensity together with vegetation cover, slope and antecedent roughness conditions are the main factors controlling the magnitude of the topographic change. These results show that TLS data sets provide new opportunities in the study of topographic change in highly erodible landscapes where the use of conventional 'invasive' topographic technologies is limited. TLS-derived morphometric sediment budgets offer distributed estimations of topographic change, permitting evaluation of the main factors controlling erosion processes. This is relevant for predictions of sediment production and, consequently, for landscape evolution modeling.