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Quantifying connectivity as a novel explanatory factor for the non-linear relationship between rainfall and erosion.

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Climate change is expected to result in rainfall events with higher intensities and volumes, influencing soil erosion rates and patterns. The order in which rainfall events occur within a sequence and antecedent conditioning also seems to affect (total) erosion and sediment yield. A possible explanation for this is the concept of connectivity; the degree of coupling between sediment sources and sinks. The aim of the research presented herein is map and formula based on the concept of connectivity; defined as the efficiency of water and sediment transport through a system, where a high connectivity corresponds to a high efficiency of transport.
A rainfall-erosion experiment was performed in the Total Environment Simulator (TES) at the University of Hull (UK) to analyze the relationships between rainfall magnitude and event sequencing with the resulting erosion. Two plots of 4.0 x 4.0 m, comprising different grain sizes, were built and a rainfall simulator, equipped with 50 nozzles, was used to generate the rain. A range of experiments where run where a total of ten different sequences consisting of five different rainfall events were used. A FARO X330 laser scanner was used to create high resolution DEMs (Digital Elevation Models), with a mean error of 1-2mm, of the evolved plot surfaces. Connectivity maps were created based on several morphological characteristics with the DEMs: 1) Slope; 2) Surface Roughness; 3) Flow accumulation; 4) Strahler order; 5) Euclidean distance to flow path; and 6) the Index of Connectivity (IC, from Borselli et al. 2008). Furthermore, the spatial variability of erosion was assessed by computing DoDs (DEMs of Difference) to the experimental initial conditions and the spatial and temporal variations in soil moisture across the plots were also measured in relation to hydrological connectivity. The processed results comprise three different maps of connectivity: the ATG (all together), VCI (Verschaeren connectivity index) and VIC (Verschaeren index of connectivity). The quality of each connectivity map, and the relationship with erosion, has been evaluated using multiple linear regression and random forest.
The results indicate that, of the three methods VIC correlated best with the observed erosion. Additionally, the regression methods were used to assess which factors relate most to volumes and patterns of plot erosion. The non-linear random forest showed improved correlations with the measurements in comparison with multiple linear regression. The VIC map can be characterized as an erodibility map. Whereas the IC (Borselli et al. 2008) can be best described as the connectivity to the outlet of the system. In the VIC, a high connectivity will be assigned to spots which are vulnerable for erosion.

Reference: Borselli, L., Cassi, P., & Torri, D. (2008). Prolegomena to sediment and flow connectivity in the landscape: a GIS and field numerical assessment. Catena, 75(3), 268-277.