



Topological invariance and spatial scaling of surface roughness in two highly eroded zones of Mexico: a comparative study

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The Fractal Image Informatics toolbox (Oleschko et al., 2008 a; Torres-Argüelles et al., 2010) was applied to extract, classify and model the topological structure and dynamics of surface roughness in two highly eroded catchments of Mexico. Both areas are affected by gully erosion (Sidorchuk, 2005) and characterized by avalanche-like matter transport. Five contrasting morphological patterns were distinguished across the slope of the bare eroded surface of Faeozem (Queretaro State) while only one (apparently independent on the slope) roughness pattern was documented for Andosol (Michoacan State). We called these patterns “the roughness clusters” and compared them in terms of metrizable, continuity, compactness, topological connectedness (global and local) and invariance, separability, and degree of ramification (Weyl, 1937). All mentioned topological measurands were correlated with the variance, skewness and kurtosis of the gray-level distribution of digital images. The morphology’ spatial dynamics of roughness clusters was measured and mapped with high precision in terms of fractal descriptors. The Hurst exponent was especially suitable to distinguish between the structure of “turtle shell” and “ramification” patterns (sediment producing zone A of the slope); as well as “honeycomb” (sediment transport zone B) and “dinosaur steps” and “corals” (sediment deposition zone C) roughness clusters. Some other structural attributes of studied patterns were also statistically different and correlated with the variance, skewness and kurtosis of gray distribution of multiscale digital images. The scale invariance of classified roughness patterns was documented inside the range of five image resolutions. We conjectured that the geometrization of erosion patterns in terms of roughness clustering might benefit the most semi-quantitative models developed for erosion and sediment yield assessments (de Vente and Poesen, 2005).

References:

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