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Qualitative and quantitative study on drainage networks at laboratory scale

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Although simulated drainage networks at the laboratory scale would represent highly-simplified models of natural drainages, they would provide a significant contribute to the comprehension of the complex dynamics governing the fluvial systems. Laboratory experiments also give the advantage to detect transient growth phases shedding some light on the knowledge of temporal and spatial landform evolution. Perhaps, pioneering laboratory experiments on drainage network evolution were carried out in 1977 at REF (Rainfall Erosion Facility) of Colorado State University by Schumm and co-workers.

This study deals with an analysis of physical experiments simulating the evolution and the development of drainage networks. To this purpose, some experiments were carried out at University of Basilicata by using a 1.5 m by 1.5 m box-basin-simulator with an outlet incised in the middle of the downslope-end side. The experimental landscape was made of a weakly cohesive soil mainly constituted by clay and silt. A system of microsprinklers generated an almost uniform artificial precipitation. Simulations were performed at a constant rainfall rate with intensity of 100 mm/h. In total four experiments were carried out. Three of those were conducted by ensuring consistent initial conditions except for the initial landscape planar slope of 9%, 5%, and 0.6%, respectively. The remaining experiment was performed with a landscape slope of 9% again, but with the (surface) base-level coinciding with the base of the outlet (i.e. streams could not erode below the base-level).

Despite the central outlet constraint, the generated stream system for the 9% plane exhibited trellis-like drainage patterns with many short tributaries joining the main stream at nearly right angles. For the 5% experiment still sub-parallel drainage patterns were formed but mainly in the centre of the watershed. Channels were clearly shallower than those of the 9% experiment. For the gentler slope of 0.6% dendritic drainage patterns developed with tributaries entering the main channel at acute angles (less than 90˚).

Digital elevation models (DEM) of the evolving landscape were achieved through detailed soil surveys with a laser pointer or a laser scanner. Then, the drainage networks were extracted from the DEMs by using the D8 algorithm.

Based on the data collected, the scaling properties of the simulated networks are analysed and compared with those of natural basins. Findings are provided mainly in terms of Hortonian laws, fractal dimensions and informational entropy. Scaling properties and space filling tendencies are discussed and peculiar differences between quasi-equilibrium and transient stages are also highlighted. Experimental evidences are also provided on the interaction between the base-level and growing mechanisms.