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# Including slope length in stochastic representations of runoff generation and connectivity under spatially variable conditions

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Hydrologic connectivity describes the influence of the intrinsic organisation of heterogeneities on the global behaviour of the hydrologic system that contains those heterogeneities. Connectivity can be usefully divided into structural connectivity, the description of continuum properties of state variables, and functional connectivity, describing the effect of heterogeneities on the rate of water transfer within such a system. In this paper we further develop and test functional connectivity equations, developed from stochastic theory, that quantify the effect of the spatial variability and arrangement of rainfall and soil properties on steady-state; i) infiltration-excess runoff delivery at a downslope boundary, and ii) the distribution of the "connected length", the upslope length with a continuous runoff pathway adjacent to the downslope boundary. The accumulation and loss of runoff down a slope is represented as a first-in first-out (FIFO) GI/G/1 queuing system; the new solutions incorporating slope length effects are analytic approximations.

Inspection of the resulting equations reveals many interesting relationships between spatial variability and runoff connectivity: for example, the runoff rate scales approximately linearly with both the square of the coefficient of variation of infiltration capacity and rainfall intensity. The connected length increases as a sigmoid function of the ratio of mean rainfall to mean infiltration capacity (known as the "traffic rate" in queue theory), with a steeper function when the spatial correlation scale is small. The analytic approximations are in excellent agreement with numerical simulations of runoff and connectivity under spatially variable conditions. The new analytic approximations are also compared with a range of data from field runoff and erosion experiments, including;

• rainfall simulations at different plot lengths (0.1, 0.25, 0.5, 1.0, & 2m) and rainfall intensities (25, 50 100, 175mm h-1) for two different soils
• 2 years of natural field erosion plot data at a range of plot lengths (0.5, 1.0, 2.0 and 4m) with 2min rainfall data
• 1 year of data from 100 runoff and erosion collectors with no artificial upper slope boundary and 2 min rainfall data

The implications of these analytic and experimental results for soil erosion modeling will be explored.