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Scaling of Peak Flows with Constant Flow Velocity in Random Self-Similar Networks

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We present a methodology to understand the role of the statistical self-similar topology of real river networks on flow hydrographs for rainfall-runoff events. Monte Carlo generated ensembles of 1000 Random Self-similar Networks (RSNs) with geometrically distributed interior and exterior generators are created. These networks emulate the topology of real networks. Hydrographs for every link in each of these networks are obtained by numerically solving the link-based mass and momentum conservation equation under the assumption of constant flow velocity. From these simulated RSNs and hydrographs, the scaling parameters for the peak of the width function β and the hydrograph peak flow ϕ are estimated. It was found that $\phi > \beta$, which supports a similar finding first reported for the Walnut Gulch basin, Arizona, and that is in qualitatively different from previous results on idealized river networks (e.g. Peano Network, Mandelbrot- Viscek Network). The use of numerical simulations is necessary as theoretical estimation of β and ϕ in RSNs is a complex mathematical open problem. However, other scaling features of the average width function can the average hydrograph are calculated analytically and compared with the estimation from the RSN-ensemble. Scaling of peak flows during individual rainfall runoff events is a new area of research that offers a path to understand regional scaling of flood quantiles, an important open problem in river network hydrology. For example, our results show an interesting connection between unit-hydrograph theory and flow dynamics. In addition, our methodology provides a reference framework to study scaling exponents under more complex scenarios of flow dynamics and runoff generation processes using ensembles of RSNs.