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A New Space-Time Rainfall Generator for Applications Over a Large Range of Space and Time Scales

B. Dodov (1) and E. Foufoula-Georgiou (1)
St. Anthony Falls Laboratory and National Center for Earth-surface Dynamics (NCED)

The seasonality and space-time intermittency of precipitation forcing have been shown recently to play a crucial role in practically all aspects of hydrologic science from landscape formation, to flood frequency scaling, to nonlinearity in hydrologic response (to mention only a few). Due to limited observations, quantifying this role is best approached through physical models where long series of spatial rainfall fields are simulated over large areas (covering basins of several orders of magnitude for a proper scaling analysis) and are converted to runoff via hydrologic transformations where necessary. This approach requires simulators that mimic the observed rainfall multiscaling structure (i.e., intermittency over a large range of scales) and the evolution of this structure with the time of the year. Current rainfall simulators fall under two categories: the multiplicative cascade generators and the phenomenological hierarchical point process models. Both these simulators are cumbersome and computationally demanding to be used for simulation at high space-time resolution over large areas and over hundreds of years. In this paper we propose an alternative space-time rainfall simulator which is based on: (i) parsimonious parameterization of the scale- and season-dependent interstorm period and scale- and season-dependent joint depth-duration PDFs of "storms" and, (ii) disaggregating each "storm" using a 3D variant of the recently developed constrained Fourier randomization procedure. The proposed approach can be seen as a data-learning simulator and it is shown to yield both visually similar and statistically indistinguishable (in terms of the rainfall anisotropic multiscaling structure as it changes over seasons). Application of this approach to simulating hourly 4x4 km rainfall fields for several centuries will be demonstrated, based on radar rainfall images of hourly accumulations scanned during the last eight years over Kansas and Oklahoma, USA. The simplicity of the proposed approach makes it appealing for application to the whole U.S using the mosaic of hourly radar scans

available since 1996.