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The use of IRP processes for modelling rainfall in space and time

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It has been observed (e.g. Veneziano et al., 2004) that space-time rainfall departs significantly from perfect multifractality. Therefore classical multifractal models, like multiplicative cascades, fail to correctly reproduce the multi-scale properties of rainfall. To obtain suitable models within a multiplicative cascade framework, one would need to make the cascade generator depend on the scale and the average rainfall intensity at some lower resolution. Besides being conceptually unappealing, such an approach requires complicated model identification and calibration procedures. In a previous presentation (Veneziano et al., EGU 2004), we advanced the hypothesis that the scaling anomalies are mainly due to the aggregation of a water-vapour condensation rate along the hydrometeor paths (mainly in the vertical direction). While the condensation rate in (x,y,z,t) may be multifractal, the vertically projected rainfall in (x,y,t) is not. Therefore, more realistic representations of rainfall should result from vertically integrating a multifractal cascade in three spatial dimensions plus time. An alternative representation, which models vertical integration indirectly and is computationally more parsimonious, is obtained by using so-called iterated random pulse (IRP) processes in (x,y,t). These processes are obtained like discrete multifractal cascades, but replace the cubic tiles with a random number of pulses with random spatial and temporal location. Here we show how a very parsimonious IRP model produces realistic looking space-time rainfall fields and matches many multi-scale properties of rainfall. The model can be easily conditioned to a large-scale “exterior” process, for example for the downscaling of GCM or LAM meteorological forecasts.