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A toy model to deal with zero rainfall in a Universal Multifractal framework

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High resolution rainfall fields contain numerous zeros (i.e pixels or time steps with no rain) which are either real or spurious that is to say associated with the limit of detection of the rainfall measurement device. The Universal multifractal (UM) framework, which is commonly used to analyse and simulate geophysical fields exhibiting extreme variability over wide range of scales with the help of reduced number of parameters, does not enable to properly represent theses zeros. It has been shown that not taking them into account can worsen the quality of the scaling and lead to severe bias in the estimates of UM parameters.

In the literature, there are mainly two models suggested for representing the zeros of the rainfall. First the so-called beta-model option, which basically consists in multiplying a multifractal field by an independent binary support (the portion of the field where there actually is some rain) generated with the help of a beta-model (i.e. a cascade model leading to a set exhibiting a pre-defined fractal dimension). Second the threshold option where the field is simply truncated at the maximum resolution. There are serious limitations with both options. For example the independence assumption in the beta-model option is not realistic and in the threshold option there is no “real” (i.e. associated with physical processes) zeros or small values.

In this paper we propose a new toy model which basically consists in merging both models. It is a UM discrete cascade process, where at each step if the simulated intensity is below a given level (defined in a scale invariant manner), it only has a predetermined probability to survive and is otherwise set to zero. It would represent a physical limit to rainfall processes. A threshold can then be implemented at the maximum resolution to model the limit of detection of the rainfall measurement device.

With the help of theoretical considerations and numerical simulations, we show that this simple toy model, while not fully satisfying, enables to accurately reproduce some features such as a scaling break observed on several rainfall data sets. We also provide tools to improve the estimates of the underlying UM parameters.