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Multifractal processes and forecasting: a rainfall case study

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Deterministic weather forecast models are still unable to adequately model the rain field, since the small scale physical processes are mostly parameterized by rather ad-doc sub-grid modelling. Furthermore, the long spin-up time of these models prevents them to deliver short term forecasts, which are indispensable in emergency situations.

The multifractal approach is physically based on the idea of cascades to take into account a hierarchy of structures and their nonlinear interactions over a wide range of space-time scales. Fundamentally, the cascade process develops higher and higher water content gradients on smaller and smaller fractions of the physical space. This approach has become possible by the successive developments of multifractal cascade models with continuous scales, scaling anisotropy between space and time and causality. These models have the advantage to have a very limited number of parameters that can be either theoretically or empirically obtained.

Due to these attractive properties, multifractal models have been more and more used for analysing or simulating rainfall. However, they had not been yet developed to the point of issuing practical rainfall forecasts, which is precisely the goal of our paper. We focus on a case study of the extreme rainfall that occurs on the 8th and the 9th of September 2002 in the Gard basin.

To achieve multifractal forecasts, we basically use the fact that at the core of a multifractal process there is a Levy white-noise, its “sub-generator”, whose future is therefore independent of its past. A first step corresponds to a backward simulation to estimate the past sub-generator from past observations (e.g. rain radar data). It raises

several technical issues due to the fact it involve inversions. The second step corresponds to a forward simulation based on the sub-generator extended to a future period. This extension can be done along several modes and we discuss those corresponding respectively to deterministic and stochastic sub-grid modelling, as well as the question of stochastic forecast vs. ensemble forecast.

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