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Multifractal assessment of the hydrological impacts of the small scale rainfall variability in an urban catchment: X-band vs. C-band radar data

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Rainfall is a very complex process that can be hardly represented with the help of a system of deterministic equations. However, it does possess non-trivial symmetries that have been more and more used to define stochastic processes modelling rainfall with the help of a few parameters that are physically meaningful. This parsimonious representation is of the upmost importance for many applications, in particular to assess the small-scale rainfall variability and its hydrological impacts.
We follow this approach to assess the interest of high-resolution rainfall measurements for a better modelling of urban and peri-urban catchments' responses. More precisely, we investigate this question with the help of multifractals applied to two types of rainfall data: C-band radar data provided by Météo-France at a resolution of 1 km in space and 5 min in time and data from a newly installed X-band radar operated by Ecole des Ponts ParisTech and providing data with a resolution of 125 m in space and 3.4 min in time. A multifractal analysis of the X-band data defines the parameter values of the multiplicative cascade to be used to downscale the C-band radar data down to the X-band data resolution. This multifractal downscaling is then used to generate an ensemble of high-resolution rainfalls whose multifractal consistency is carefully checked. They are thereafter input into a validated hydrological model to obtain a large ensemble of hydrographs (e.g. a hundred of them), whose consistency with the responses to the X-band data is again carefully checked, as well as with empirical hydrological data.
The variability observed within the simulated ensemble corresponds to the hydrological impact of the small-scale rainfall variability that is not measured by the C-band radar. These impacts are characterised with the help of classical statistics and multifractal analysis. We show that the fully distributed hydrological models and their multifractal analysis tend to give more insights, particularly for the extremes.