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Variability of multifractal parameters in an urban precipitation monitoring network

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Precipitation especially over urban areas is considered a highly non-linear process, with wide variability over a broad range of temporal and spatial scales. Despite obvious limitations of rainfall gauges location at urban sites, rainfall monitoring by gauge networks is a standard solution of urban hydrology. Often urban precipitation gauge networks are formed by modern electronic gauges and connected to control units of centralized urban drainage systems. Precipitation data, recorded online through these gauge networks, are used in so called Real-Time-Control (RTC) systems for the development of optimal strategies of urban drainage outflows management. As a matter of fact, the operation of RTC systems is motivated mainly by the urge of reducing the severity of urban floods and combined sewerage overflows, but at the same time, it creates new valuable precipitation data sources.

The variability of precipitation process could be achieved by investigating multifractal behavior displayed by the temporal structure of precipitation data. There are multiply scientific communications concerning multifractal properties of point-rainfall data from different worldwide locations. However, very little is known about the close variability of multifractal parameters among closely located gauges, at the distances of single kilometers.

Having this in mind, here we assess the variability of multifractal parameters among gauges of the urban precipitation monitoring network in Warsaw, Poland. We base our analysis on the set of 1-minute rainfall time series recorded in the period 2008-2011 by 25 electronic weighing type gauges deployed around the city by the Municipal Water Supply and Sewerage Company in Warsaw as a part of local RTC system.

The presence of scale invariance and multifractal properties in the precipitation process was investigated with spectral analysis, functional box counting method and studying the probability distributions and statistical moments of the rainfall intensities. The empirical multifractal scaling exponent functions were derived, and theoretical universal multifractal model based on Lèvy stochastic variables was applied. The cluster analysis was finally used for the grouping of the precipitation gauges. It was possible to identify groups of similar gauges, as well as to explain the anomalous behavior of some gauges partly by the specific location or the influence of local conditions.