Combined spatio-temporal multifractal analysis of radar rainfall and simulated surface runoff

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In this paper we suggest to use scaling laws and more specifically Universal Multifractals (UM) to analyse in a spatio-temporal framework both the radar rainfall and the simulated surface runoff. Such tools have been extensively used to analyse and simulate geophysical fields extremely variable over wide range of spatio-temporal scales such as rainfall, but have not often if ever been applied to surface runoff. Such novel combined analysis helps to improve the understanding of the rainfall-runoff relationship.

Two catchment of the European Interreg IV RainGain project are used. They are both located in the Paris area: a 144 ha flat urban area in the Seine-Saint-Denis County, and a 250 ha urban area with a significant portion of forest located on a steep hillside of the Bièvre River. Three rainfall events that occurred in 2010 and 2011, for which the Météo-France radar mosaic with a resolution of 1 km in space and 5 min in time is available, are analysed. They generated significant surface runoff and some local flooding. A fully distributed urban hydrological model currently under development called Multi-Hydro is implemented to represent the catchments response. It consists in an interacting core between open source software packages, each of them representing a portion of the water cycle in urban environment.

The fully distributed model is tested with pixels of size 5, 10 and 20 m. The observed multifractal properties of rainfall are used to stochastically downscale this input field at higher resolutions simply by continuing the underlying cascade process which is observed on the available range of scales. It appears that the outputs (maps of water depth and velocity) of the hydrological model exhibit a scaling behaviour both in space and time. The three UM parameters of the various processes at stake are then compared which enables to analyse how the extremes are either dampened or enhanced. This hints at innovative techniques to quantify the extremes at very high resolution (typically 1 m) without having to run the model at these resolutions which would require too much time especially for real time applications.