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Scale effect challenges in urban hydrology highlighted with a Fully Distributed Model and High-resolution rainfall data

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Nowadays, there is a growing interest on small-scale rainfall information, provided by weather radars, to be used in urban water management and decision-making. Therefore, an increasing interest is in parallel devoted to the development of fully distributed and grid-based models following the increase of computation capabilities, the availability of high-resolution GIS information needed for such models implementation. However, the choice of an appropriate implementation scale to integrate the catchment heterogeneity and the whole measured rainfall variability provided by High-resolution radar technologies still issues. This work proposes a two steps investigation of scale effects in urban hydrology and its effects on modeling works.

In the first step fractal tools are used to highlight the scale dependency observed within distributed data used to describe the catchment heterogeneity, both the structure of the sewer network and the distribution of impervious areas are analyzed. Then an intensive multi-scale modeling work is carried out to understand scaling effects on hydrological model performance. Investigations were conducted using a fully distributed and physically based model, Multi-Hydro, developed at Ecole des Ponts ParisTech. The model was implemented at 17 spatial resolutions ranging from 100 m to 5 m and modeling investigations were performed using both rain gauge rainfall information as well as high resolution X band radar data in order to assess the sensitivity of the model to small scale rainfall variability.

Results coming out from this work demonstrate scale effect challenges in urban hydrology modeling. In fact, fractal concept highlights the scale dependency observed within distributed data used to implement hydrological models. Patterns of geophysical data change when we change the observation pixel size. The multi-scale modeling investigation performed with Multi-Hydro model at 17 spatial resolutions confirms scaling effect on hydrological model performance. Results were analyzed at three ranges of scales identified in the fractal analysis and confirmed in the modeling work. The sensitivity of the model to small-scale rainfall variability was discussed as well.