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Required spatial resolution of hydrological models to evaluate urban flood resilience measures

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During a flood in urban area, several non-linear processes (rainfall, surface runoff, sewer flow, and sub-surface flow) interact. Fully distributed hydrological models are a useful tool to better understand these complex interactions between natural processes and man built environment. Developing an efficient model is a first step to improve the understanding of flood resilience in urban area. Given that the previously mentioned underlying physical phenomenon exhibit different relevant scales, determining the required spatial resolution of such model is tricky but necessary issue. For instance such model should be able to properly represent large scale effects of local scale flood resilience measures such as stop logs. The model should also be as simple as possible without being simplistic. In this paper we test two types of model.
First we use an operational semi-distributed model over a 3400 ha peri-urban area located in Seine-Saint-Denis (North-East of Paris). In this model, the area is divided into sub-catchments of average size 17 ha that are considered as homogenous, and only the sewer discharge is modelled. The rainfall data, whose resolution is 1 km is space and 5 min in time, comes from the C-band radar of Trappes, located in the West of Paris, and operated by Météo-France. It was shown that the spatial resolution of both the model and the rainfall field did not enable to fully grasp the small scale rainfall variability. To achieve this, first an ensemble of realistic rainfall fields downscaled to a resolution of 100 m is generated with the help of multifractal space-time cascades whose characteristic exponents are estimated on the available radar data. Second the corresponding ensemble of sewer hydrographs is simulated by inputting each rainfall realization to the model. It appears that the probability distribution of the simulated peak flow exhibits a power-law behaviour. This indicates that there is a great uncertainty associated with small scale rainfall.
Second we focus on a 50 ha catchment of this area and implement Multi-Hydro, a fully distributed urban hydrological model currently being developed at Ecole des Ponts ParisTech (El Tabach et al., 2009). The version used in this paper consists in an interactive coupling between a 2D model representing infiltration and surface runoff (TREX, Two dimensional Runoff, Erosion and eXport model, Velleux et al., 2011) and a 1D model of sewer networks (SWMM, Storm Water Management Model, Rossman, 2007). Spatial resolution ranging from 2 m to 50 m for land use, topography and rainfall are tested. A special highlight on the impact of small scales rainfall is done. To achieve this the previously mentioned methodology is implemented with rainfall fields downscaled to 10 m in space and 20 s in time.
Finally, we will discuss the gains generated by the implementation of the fully distributed model.