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High resolution modeling in urban hydrology: comparison between two modeling approaches and their sensitivity to high rainfall variability

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Urban water management is becoming increasingly complex, due to the rapid increase of impervious areas, and the potential effects of climate change. The large amount of water generated in a very short period of time and the limited capacity of sewer systems increase the vulnerability of urban environments to flooding risk and make it necessary to implement specific devices in order to handle the volume of water generated. This complex situation in urban environments makes the use of hydrological models as well as the implementation of more accurate and reliable tools for flow and rainfall measurements essential for a good pluvial network management, the use of decision support tools such as real-time radar forecasting system, the developpement of general public communication and warning systems, and the implementation of management strategy participate on limiting the flood damages. The very high spatial variability characteristic of urban environments makes it necessary to integrate the variability of physical properties and precipitation at fine scales in modeling processes, suggesting a high resolution modeling approach.

In this paper we suggest a comparison between two modeling approaches and their sensitivity to small-scale rainfall variability on a 2.15 km2 urban area located in the County of Val-de-Marne (South-East of Paris, France). The first model used in this study is CANOE, which is a semi-distributed model widely used in France by practitioners for urban hydrology and urban water management. Two configurations of this model are be used in this study, the first one integrate 9 sub-catchments with sizes range from (1ha to 76ha), in the second configuration, the spatial resolution of this model has been improved with 45 sub-catchments with sizes range from (1ha to 14ha), the aim is to see how the semi-distributed model resolution affects it sensitivity to rainfall variability. The second model is Multi-Hydro fully distributed model developed at the Ecole des Ponts ParisTech. It is an interacting core between open source software packages, each of them representing a portion of the water cycle in urban environment. Multi-Hydro has been set up at two resolutions, 10m and 5m.

The validation of these two models is performed using 5 rainfall events that occurred between 2010 and 2013. Radar data comes from the Météo-France radar mosaic and the resolution is 1 km in space and 5 min in time. Raingauge and flow measurements data comes from the General Council of Val-de-Marne County. In this validation part, the hydrological responses given by two models and the different configurations are compared to flow measurements. It appears that CANOE gives better results than Multi-Hydro model, especially when using raingauge data. For some events, we noticed that model responses given when using raingauge and radar data are different, suggesting a sign of sensitivity to the spatial variability of rainfall.

10 high-resolution rainfall events are used in the second part to study the sensitivity of each modeling approach to high rainfall variability. Radar data was available at four spatial resolutions (100, 200, 500 and 1000m) and two temporal resolutions (1min and 5min), for each event, two rainfall directions (parallel and perpendicular) are used, meaning that 16 hydrological responses are simulated for each event and the variability within it analyzed. First results suggest that the fully distributed model is more sensitive to high rainfall variability than the semi-distributed one, the increase of both hydrological model spatial resolution improves their sensitivity to rainfall variability. This study highlights some technical challenges facing the high-resolution modeling, especially the difficulty to obtain reliable input data at an acceptable resolution and also the high computation time noticed particularly for the semi-distributed model making it difficult to use it in real time.

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