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Lessons learned from combined experimental and numerical modelling of urban floods

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Field data for validating hydraulic models remain scarce. They are often limited to inundation extents and water marks, which provide little insights into the dynamic features of the flow in urbanized floodplains, such as the discharge partition in-between the streets and the velocity fields. To address this issue, a unique experimental setup representing a whole urban district was built in the laboratory ICube in Strasbourg and the state-of-the-art shallow-water model Wolf 2D was tested against the experimental measurements (Arrault et al. 2016). The numerical model was also used to extend and refine the analysis of the laboratory observations.

The experimental model (5 m $\times$ 5 m) represents a square urban district with a total of 14 streets of different widths and 49 intersections (crossroads). The inflow discharge can be controlled in each street individually and the outflow discharges were measured downstream of each street. The numerical model Wolf was developed at the University of Liege and has been extensively used in flood risk research (Beckers et al. 2013, Bruwier et al. 2015, Detrembleur et al. 2015).

Several lessons could be learned from this combined experimental and numerical analysis. First, we found that the discharge partition in-between the streets is primarily controlled by the street widths. Second, although the standard shallow-water equations reproduce satisfactorily most of the flow characteristics, adding a turbulence model improves the prediction of the shape and length of the flow recirculations in the streets. Yet, this has little influence on the discharge partition because the computed recirculation widths are hardly affected by the turbulence model.

The experiments and the numerical model also show that the water depths in the streets remain fairly constant in-between two intersections, while they drop suddenly downstream of each intersection as a result of complex flow interactions at the intersections. This hints that friction has little influence on the water depths obtained in the experiments. However, tailored numerical tests demonstrate that this is a direct consequence of the distorted nature of the experimental setup. Indeed, the ratio between the water depth and the street width is close to 1 in the experiments, while it would be at least one order of magnitude lower in real-world conditions, even for extreme floods.

Finally, remote sensing data, such as digital elevation models, are generally available on a regular grid, which makes it convenient to use also a Cartesian grid for hydraulic modelling. We show here that the discretization of the geometry of the buildings on such a Cartesian grid has a major influence on the modelling accuracy (overestimation of the overall flow resistance). An extended shallow-water model based on non-isotropic porosity parameters is shown to improve substantially the prediction of the discharge partition in-between the streets. It is therefore considered as a valuable tool to advance urban flood modelling in practice.

From the lessons learned here, we recommend that future research focuses on the design and exploitation of a less distorted experimental model, as well as on the analysis of extra flow processes such as transient conditions and interactions between overland flow and pressurized flow in underground passages.

References

Arrault, A., Finaud-Guyot, P., Archambeau, P., Bruwier, M., Erpicum, S., Pirotton, M., & Dewals, B. (2016). Hydrodynamics of long-duration urban ?oods: experiments and numerical modelling. *Natural Hazards & Earth System Sciences, 16*, 1413-1429.

Beckers, A., Dewals, B., Erpicum, S., Dujardin, S., Detrembleur, S., Teller, J., Pirotton, M., & Archambeau, P. (2013). Contribution of land use changes to future flood damage along the river Meuse in the Walloon region. *Natural Hazards & Earth System Sciences, 13*, 2301-2318.

Bruwier, M., Erpicum, S., Pirotton, M., Archambeau, P., & Dewals, B. (2015). Assessing the operation rules of a reservoir system based on a detailed modelling chain. *Natural Hazards & Earth System Sciences, 15*, 365-379.

Detrembleur, S., Stilmant, F., Dewals, B., Erpicum, S., Archambeau, P., & Pirotton, M. (2015). Impacts of climate change on future flood damage on the river Meuse, with a distributed uncertainty analysis. *Natural Hazards, 77*(3), 1533-1549.

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