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Uncertainties in laboratory modelling of urban flooding

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Worldwide, flood losses are particularly severe in urban environments. To support urban flood risk management, accurate risk modelling tools are needed; but such tools remain limited by a lack of reliable field validation data. Although this is particularly true for the vulnerability component of the models, it holds also for the hazard component. Indeed, mostly watermarks and aerial imagery are available as well as recent crowd-sourced data; but these are insufficient to inform on the velocity fields and discharge partitions in-between the streets, while these parameters are critical inputs for flood impact modelling (e.g. structural damage to buildings, instability of pedestrians, contaminant transport…).

We argue that laboratory data [1] are a valuable complement to field data for validating urban flooding simulations, because they enable distributed measurements of flow characteristics under controlled conditions. Yet, the use of laboratory scale modelling for generating truly representative validation data poses also a number of challenges.

In the first part of this communication, we will discuss the main uncertainties affecting laboratory scale modelling of urban flooding and their relative importance. These include uncertainties in hydrological data, on roughness representation, on exchanges between overland flow and the drainage network, measurement uncertainties as well as the influence of overlooked processes (storage within the buildings, effect of urban furniture…).

In a second part, we will focus on the issue of scaling, particularly for lab experiments representing urban flooding at the district level. Urban flooding is a genuinely multi-scale process: an urban district extends typically over 10^2 to 10^4 m, whereas the water depths of interest are of the order of 10^{-2} to 1 m. Consequently, laboratory scale models of urban flooding tend to use distinct scale factors (ratio between prototype and model dimensions) along the horizontal and vertical directions (to avoid millimetre-scale water depths in the lab, or giant lab setups hardly possible to fit in a hydraulic lab). This leads to so-called geometrically distorted scale models. It is believed that this strategy ensures improved accuracy and representativeness of the measurements; but specific artefacts (e.g. the alteration of 2D and 3D flow structure etc.) also arise from the model distortion.

These effects were never studied so far. Here, we provide first quantitative insights into the effects of model distortion, based on a recent reanalysis of existing experimental datasets [2]. In the tested configurations, the influence of model distortion on the predicted values of water depth and street discharges is found of the order of 10%, which is higher than the measurement inaccuracies, but comparable to other uncertainties in the modelling process (e.g. uncertainties in hydrological data).

We will conclude with recommendations on the way to go to make the optimal use of laboratory scale modelling for addressing the needs of the flood risk community.

References

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[2] Li, X. et al.: Laboratory modelling of urban flooding: strengths and challenges of distorted scale models, *Hydrol Earth Syst Sci Diss*, 2018, doi:10.5194/hess-2018-484.