Methodology for qualitative urban flooding risk assessment

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ABSTRACT

Pluvial or surface flooding can cause significant damage and disruption as it often affects highly urbanised areas. Therefore it is essential to accurately identify consequences and assess the risks associated with such phenomena. The aim of this study is to present the results and investigate the applicability of a qualitative flood risk assessment methodology in urban areas. This methodology benefits from recent developments in urban flood modelling, such as the dual-drainage modelling concept, namely one-dimensional automatic overland flow network delineation tools (e.g. AOFD) and 1D/1D models incorporating both surface and sewer drainage systems. To assess flood risk, the consequences can be estimated using hydraulic model results, such as water velocities and water depth results; the likelihood was estimated based on the return period of historical rainfall events. To test the methodology two rainfall events with return periods of 350 and 2 years observed in Alcântara (Lisbon, Portugal) were used and three consequence dimensions were considered: affected public transportation services, affected properties and pedestrian safety. The most affected areas in terms of flooding were easily identified; the presented methodology was shown to be easy to implement and effective to assess flooding risk in urban areas, despite the common difficulties in obtaining data.

Key words | 1D/1D urban drainage modelling, flood modelling, risk assessment, surface urban flooding

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INTRODUCTION

Urban pluvial flooding has the potential to cause significant damage and disruption as it often occurs in highly urbanised areas (residential, commercial or industrial occupation). Due to the density and complexity of the urban built environment, it is essential to accurately identify flood-vulnerable areas. Flooding frequency is expected to increase due not only to urbanisation but also to expected climate changes (Ugarelli *et al.* 2011).

Recent developments in urban flood modelling (e.g. Leitão 2009; Maksimović *et al.* 2009) allow carrying out of reliable simulations of the whole drainage system, including both sewer and surface drainage systems. Developments are based on the dual-drainage modelling concept (Djordjević *et al.* 2005) to simulate the interactions between the two systems. This concept is essential to accurately simulate flooding conditions, including interactions between the two drainage systems during flood events. Implementation can be supported by one- or two-dimensional (1D or 2D) representations of the surface drainage system. The 1D approach represents the surface drainage system as a set of 1D flow paths and 2D terrain depressions, representing flood-prone areas (Maksimović *et al.* 2009). The latter approach represents the surface as a 2D mesh; the water flows over the mesh, accumulating in terrain depressions (e.g. Chen *et al.* 2007; Innovyze 2011). To set up a dual-drainage model, the sewer system is coupled with a surface drainage system (1D or 2D approach). Simulations are then carried out simultaneously on both systems' models. Despite the good results that can be obtained using 1D/2D models, run-time may be extremely long (Leitão *et al.* 2010), especially if the number of mesh elements is large. 1D/1D models are fast but results may be less detailed and less accurate than those obtained using 1D/2D models (Leitão *et al.* 2010; Simões *et al.* 2010).

Several references can be found (e.g. Apel *et al.* 2009; Douglas *et al.* 2010) with examples of usage of urban drainage modelling to estimate the consequences of flooding and

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