On the use of semi-distributed and fully-distributed urban stormwater models

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Abstract
Urban stormwater models comprise four main components: rainfall, rainfall-runoff, overland flow and sewer flow modules. They can be considered semi-distributed (SD) or fully distributed (FD) according to the rainfall-runoff module definition. SD models are based on sub-catchments units through which rainfall is applied to the model and at which runoff volumes are estimated. In FD models, the runoff volumes are estimated and applied directly on every element of a two-dimensional (2D) model of the surface. This poster presents a comparison of SD and FD models based on two case studies: Zona Central catchment at Coimbra, Portugal, and Cranbrook catchment at London, UK. SD and FD modelling results are compared against water depth and flow records in sewers, and photographic records of a flood event. In general, FD models are theoretically more realistic and physically-based, but the results of this study suggest that the implementation of these models requires higher resolution (more detailed) elevation, land use and sewer network data than is normally used in the implementation of SD models. Failing to use higher resolution data for the implementation of FD models could result in poor-performing models. In cases when high resolution data are not available, the use of SD models could be a better choice.

Keywords
1D2D, fully-distributed models, rainfall-runoff modelling, semi-distributed models, urban drainage, urban stormwater

BACKGROUND AND RELEVANCE
Traditional urban stormwater models are usually based on a sewer flow module linked to a simple rainfall-runoff model (1D models) and eventually connected with an overland flow module (1D2D or 1D1D models). In most situations, the urban catchment has been divided in smaller sub-catchments units with hydrological parameters to define SD runoff routing volumes that discharge directly in the nodes of the sewer system. However, the increase of data available (e.g. digital map), the advances in technology (e.g. computing techniques) and the continuous improvements of numerical methods (e.g. reduce of simulation times) bring new opportunities for rainfall-runoff and overland flow modules (Delleur, 2003; Price et al., 2011; M. Smith, 2006; M. B. Smith, 2006). In addition, the recent developments enabled the direct connection between these two modules with FD models, allowing the runoff routing to be performed directly with the overland flow modules.
This poster presents a comparison between 1D2D SD and 1D2D FD urban stormwater models based on two real case studies. Modelling results are compared against observed data leading to conclusions on the use of SD and FD models.
RESULTS AND DISCUSSION

The 1D2D SD and 1D2D FD models were implemented in Infoworks ICM vs. 5.5 for two real case studies: Zona Central, Coimbra, Portugal and Cranbrook, London, UK.

The Zona Central catchment (Figure 1) is located in the downtown area of Coimbra, Portugal. It has a total area of approximately 1.5 km2 and the sewer system is nearly 35 km long, most of which is combined. The rainfall in the area is being continuously monitoring with rain gauges and water depth sensors recorded data in two main location of the sewer network during 2011.

The Cranbrook case study (Figure 2) is located in the suburbs of London, UK. It has a total area of approximately 8.7 km2 and the stormwater sewer system is nearly 98 km long. This catchment is being monitored for the RainGain project (www.raingain.eu) with two flow gauges and three water level sensors in sewers and four rain gauges.

The results for these two catchments are presented and compared against observed data. Figure 3 plots modelling results against observed data on 8 January 2015 in the Cranbrook case study. In general, for all the monitoring points, FD model tends to underestimate water depth and flows in sewers, while the SD results are closer to observed data and predict peak values with more accuracy. Figure 4 presents a comparison between modelling results and a real floodplain generated on 9 June 2006 at Zona Central case study. In general, the floodplain is well captured by the SD model and underestimated by the FD one. This is justified due to sparse details of sewer inlets in the FD model, which leads to the retention of surface runoff volumes in upstream areas that do not flow to lower zones (where the surface runoff accumulates in reality).

In conclusion, results suggest that FD models are more sensitive to surface storage and require higher detail of the sewer network. In applications when high-resolution data are not available, the use of SD models could be a better choice, or a combination of SD on urbanized areas with FD models on open areas could be applied.

Figure 1. “Zona Central” catchment – Coimbra, Portugal: sewer network, DTM and monitoring point locations (left); land use data (right).
Figure 2. “Cranbrook” catchment – London, UK: sewer network, DTM and monitoring point locations (left); land use data (right).
Figure 3. Observed data and modelling results in the sewer network in the Cranbrook catchment on 8 January 2015.

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<tr>
<th>Photographic evidence</th>
<th>SD model</th>
<th>FD model</th>
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<td><img src="image1.png" alt="Photographic evidence" /></td>
<td><img src="image2.png" alt="SD model" /></td>
<td><img src="image3.png" alt="FD model" /></td>
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Figure 4. Comparison of modelling results with the observed floodplain on 9 June 2006 in the Coimbra case study.

**ACKNOWLEDGEMENT**
Rui Pina acknowledges the financial support from the Fundação para a Ciência e Tecnologia - Ministério para a Ciência, Tecnologia e Ensino Superior, Portugal [SFRH/BD/88532/2012]. Susana Ochoa-Rodriguez acknowledges the support of the Interreg IVB NWE RainGain project. Special thanks are due to AC, Águas de Coimbra for providing rainfall and sewer data of the pilot location and to Innovyze for providing research licences of InfoWorks ICM software.

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