SEMI- VS. FULLY-DISTRIBUTED URBAN STORMWATER MODELS

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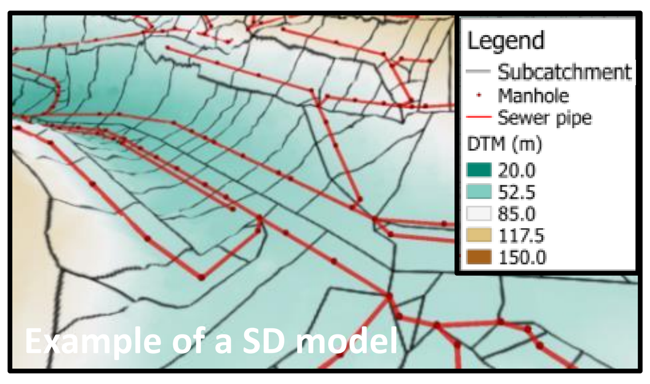
Abstract

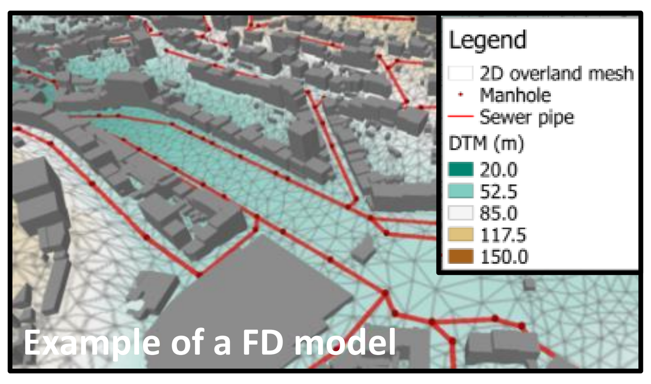
Urban stormwater models are important tools for flood simulation, prediction and management. Their main input is rainfall data, the temporal and spatial resolution of which must be in agreement with that of the hydrological/hydraulic model. Fully distributed (FD) urban stormwater models are generally more detailed and physically-based than the commonly used semi-distributed (SD) models. In this work a comparison is presented of SD and FD models based on two real case studies in UK and Portugal.

SD and FD models



Example of a SD model

SD models are based on sub-catchment discretisation, through which rainfall (assumed to be uniform within each subcatchment) is applied to the model. Runoff volumes are estimated and routed within each subcatchment based on empirical or conceptual methods.
FD models are based on two-dimensional representations of the overland surface, where the rainfall is applied directly onto each mesh element and runoff volumes are applied and routed.
A methodology to build comparable SD and FD models was developed and similar data were collected at both case studies.



Example of a FD model

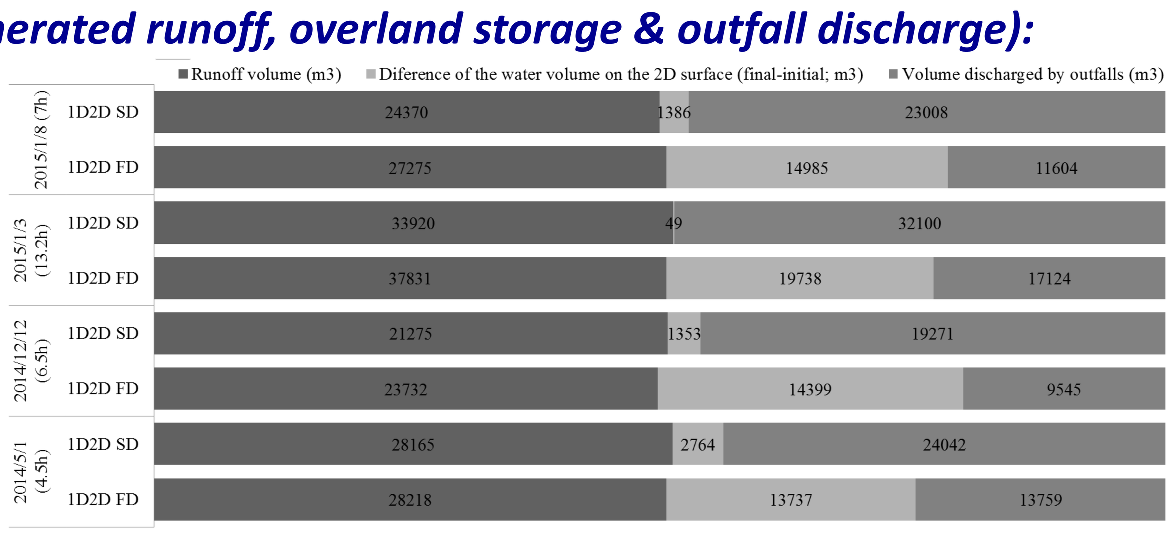
Cranbrook case study, London, UK

The comparison between the SD and FD model of Cranbrook case study was based on 3 storm events for which local rainfall and runoff data were available:

Event	Time			Rainfall		
	Start	End	Duration (h)	Maximum intensity (mm/h)	Total (mm)	Average intensity (mm/h)
141212	12/12/2014 01:30	12/12/2014 08:00	6.5	12	10.9	2
150103	03/01/2015 03:50	03/01/2015 17:00	13.2	12	16.6	1
150108	08/01/2015 07:30	08/01/2015 14:30	7.0	12	11.6	2

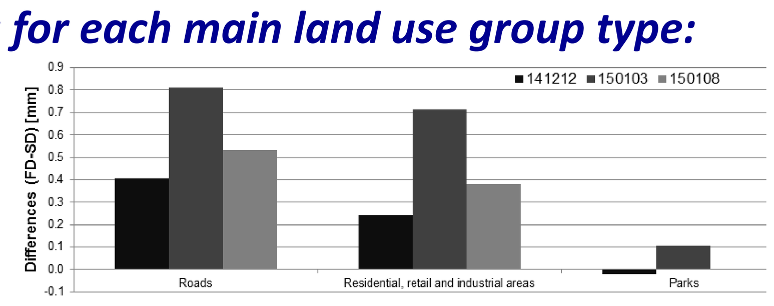
Volume balance (generated runoff, overland storage & outfall discharge):

- Runoff volumes generated in both models are very similar.
- The FD model has a significantly higher overland storage, which translates into smaller discharge through outfalls of the sewer system.



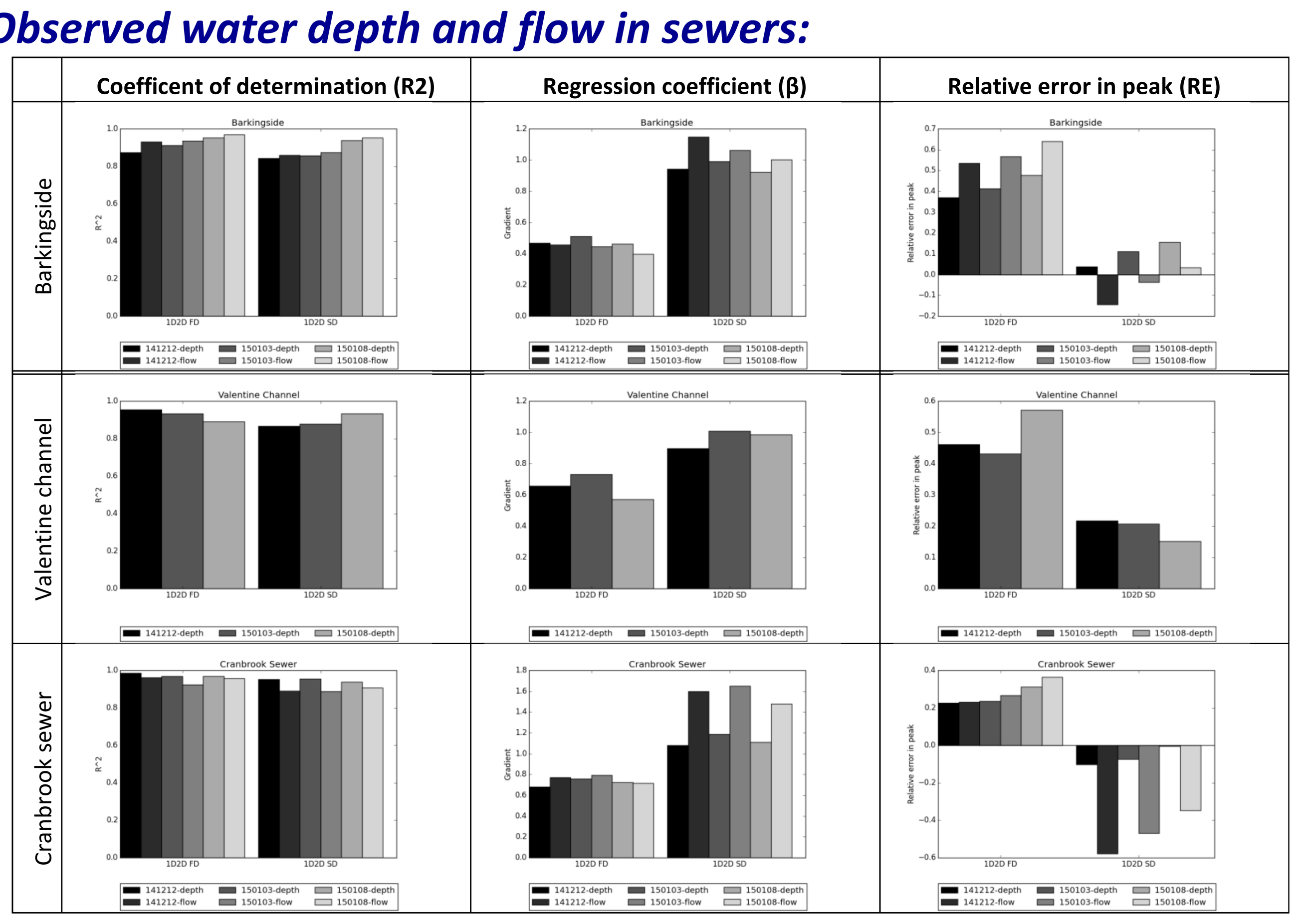
Difference in maximum overland volumes for each main land use group type:

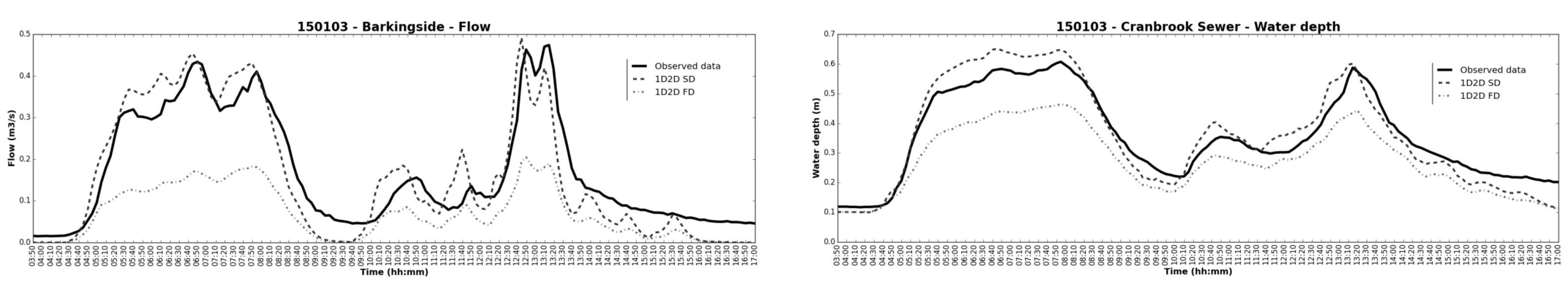
FD model has higher overland volumes on roads and on urbanised areas. This is due to water being retained in singularities within the 2D overland model (e.g. around buildings)



Simulated vs. Observed water depth and flow in sewers:

FD model tends to underestimate water depths and flows in sewers, while the SD results are closer to observed data and predict peak values with more accuracy.





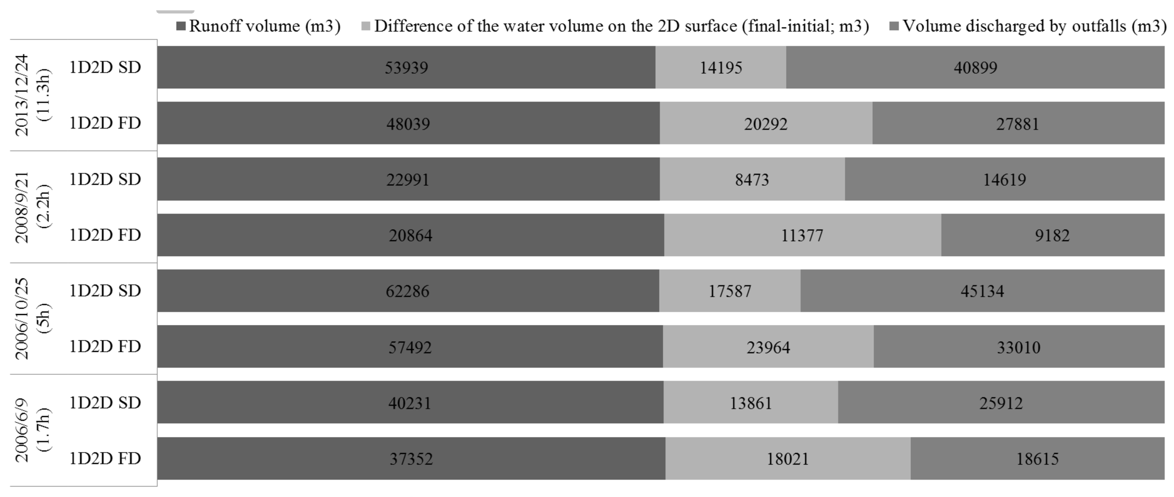
Zona Central case study, Coimbra, Portugal

The comparison between the SD and FD model of Zona Central case study was based on 4 flooding events:

Event	Return period (yr)	Time			Rainfall		
		Start	End	Duration (h)	Maximum intensity (mm/h)	Total (mm)	Average intensity (mm/h)
060609	50	09/06/2006 14:50	09/06/2006 16:30	1.7	144.0	36.6	22.0
061025	50	25/10/2006 00:30	25/10/2006 05:30	5.0	102.0	56.6	11.3
080921	5	21/09/2008 15:10	21/09/2008 17:20	2.2	60.6	21.4	9.9
131224	5	24/12/2013 06:40	24/12/2013 18:00	11.3	31.5	48.9	4.3

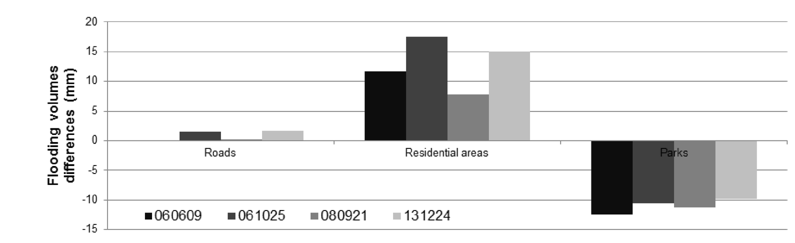
Volume balance (generated runoff, overland storage & outfall discharge):

Same as in Cranbrook, the FD model stores more runoff in the overland. However, in this case study, the difference between both models is smaller than in Cranbrook.



Difference in maximum overland volumes for each main land use group type:

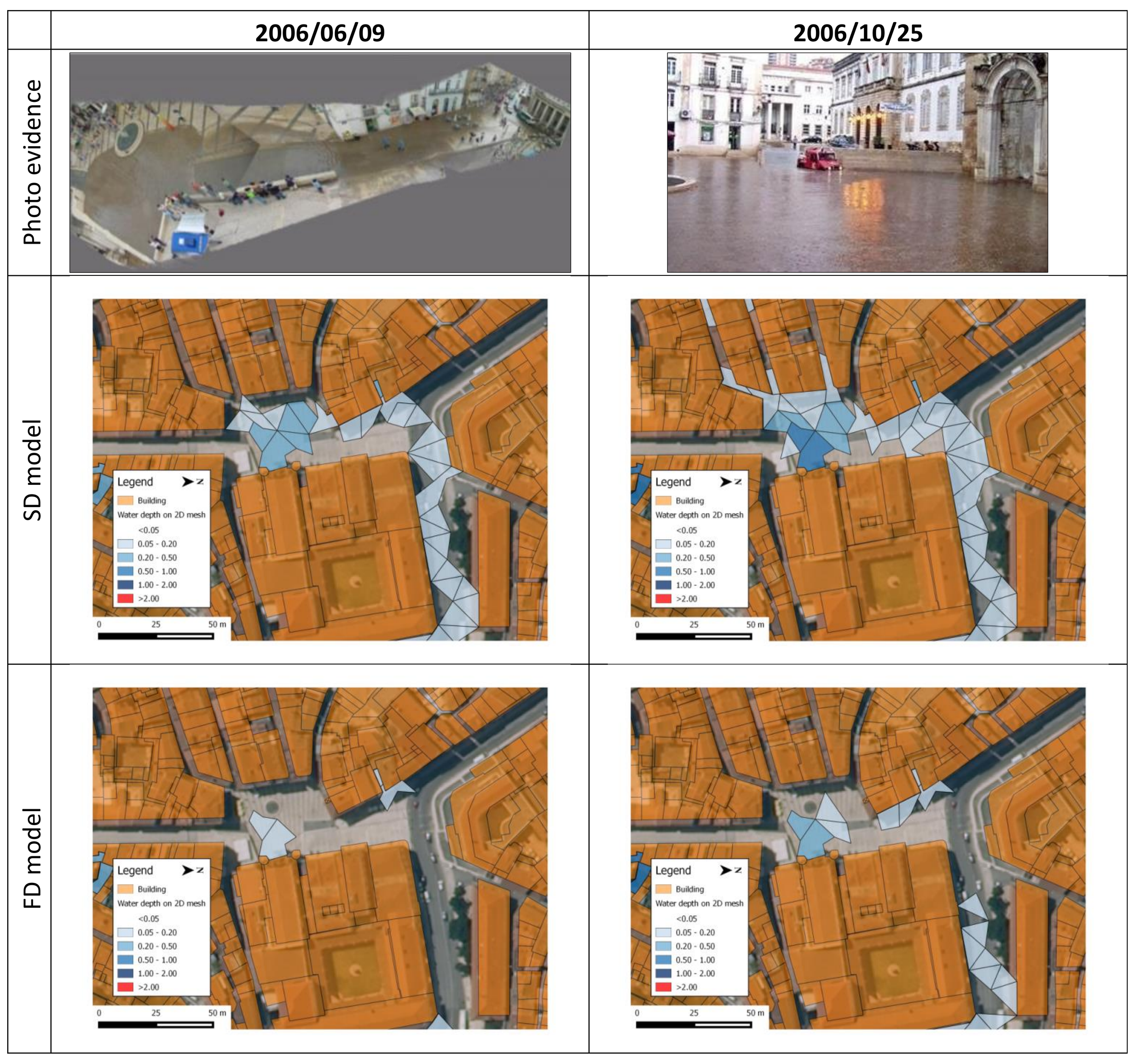
The FD model shows higher flooding volumes in residential areas as compared to the SD model. This is likely because private (building) connections to the sewer system are not represented. Therefore, runoff generated on the 2D overland model never reaches the sewer system and stays on the overland.



This suggest that correct implementation of FD models requires higher detail of the sewer network.

Floodplains at the city centre (8 de Maio Square) for the events with highest return period:

Floodplains on the 8 Maio Square are well captured by the SD model and underestimated by the FD one. Due to sparse details of sewer inlets and private connections, in the FD model surface runoff volumes are retained in upstream areas and do not flow to lower zones (where the surface runoff accumulates in reality).



Conclusions

Results suggest that FD models are more sensitive to surface storage and their implementation requires higher detail of the sewer network. Failure to represent the sewer system in detail may lead to misrepresentation of runoff processes in FD models. 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.

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