

Fully-distributed vs. Semi-distributed urban drainage models

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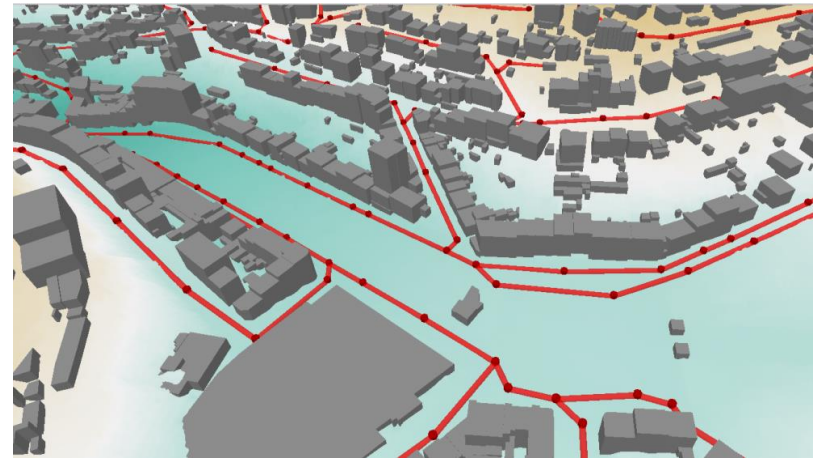
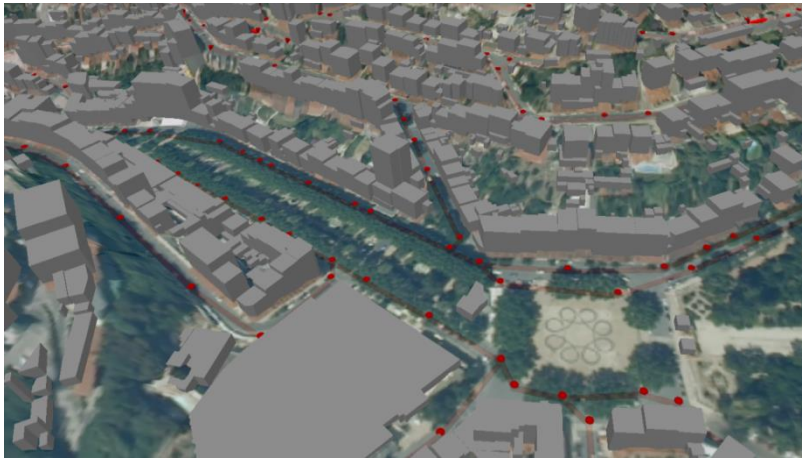
RainGain International Workshop on Urban Pluvial Flood Models
Exeter, 6th October 2014



1. INTRODUCTION & OBJECTIVES



1D-2D Dual drainage



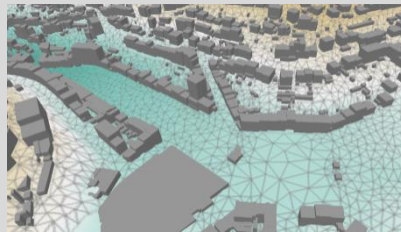
Main modules: rainfall, rainfall-runoff, overland flow, sewer flow



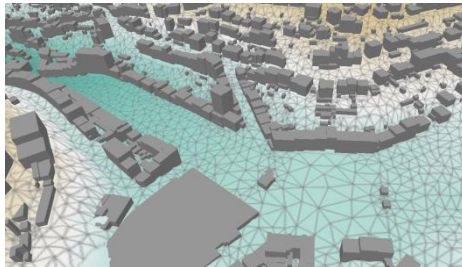
1D2D Dual drainage modules



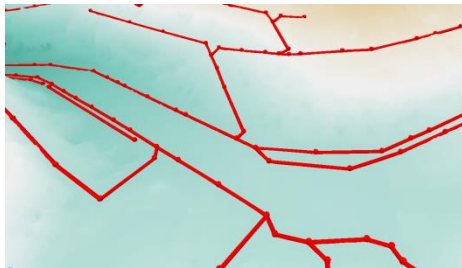
Rainfall



Rainfall-runoff



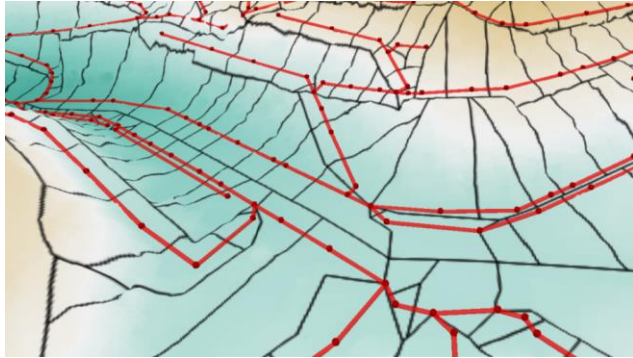
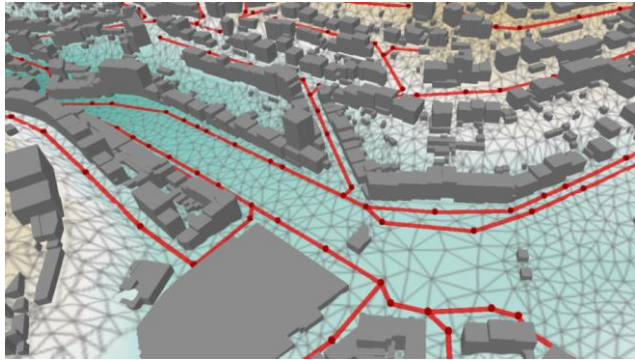
(2D) Overland flow



(1D) Sewer flow

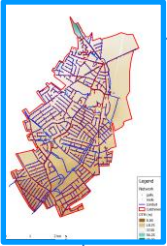


Rainfall-Runoff models

DIFFERENCES	SEMI – DISTRIBUTED (SD)	FULLY – DISTRIBUTED (FD)
		
How rainfall is inputted	Through subcatchments	Directly onto each element of 2D overland model
How runoff volume is estimated	At subcatchment scale	At each element of 2D overland model
How runoff is routed	At subcatchment scale	Through 2D routing of overland flow
How/when runoff reaches the surface	When inlet capacity is insufficient, when sewers surcharge	As soon as runoff is generated



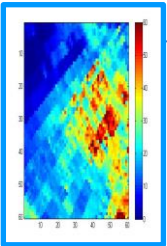
Objectives



Implement comparable SD and FD models



SD and FD performance and requirements?



Impact of rainfall input resolution?



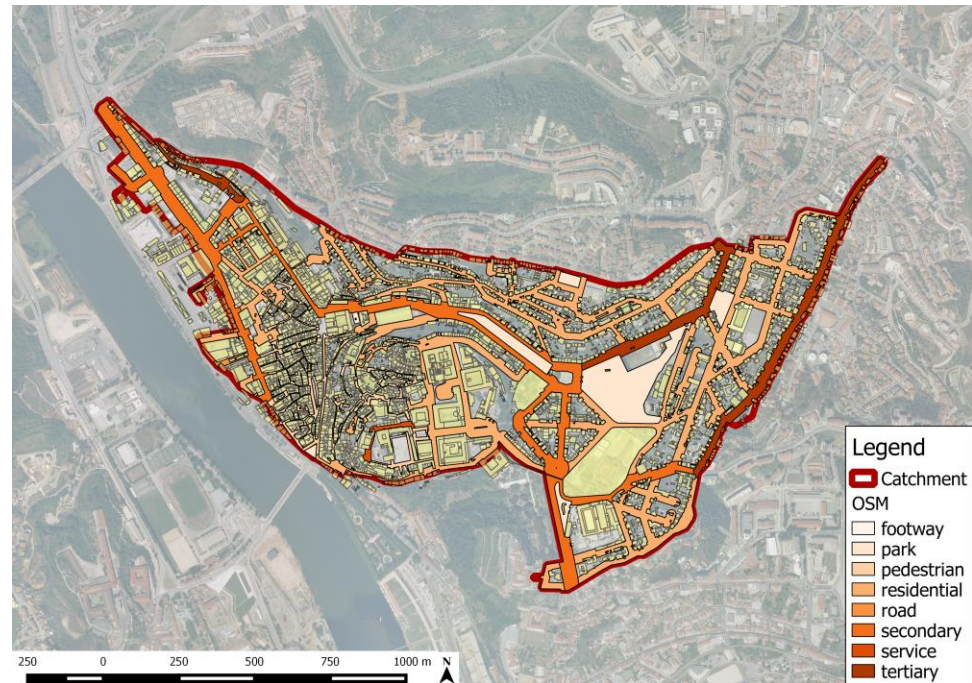
2. METHODOLOGY

- Input datasets
- Model building

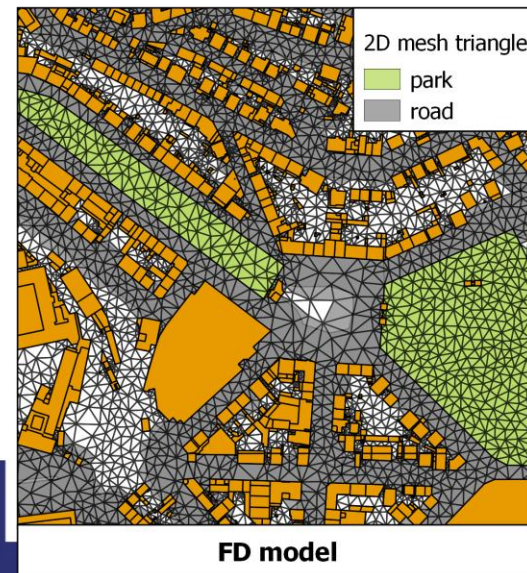
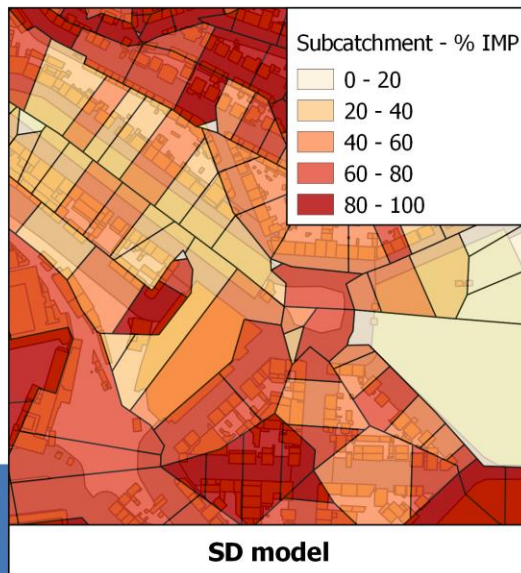


Input datasets

- **(1D) Sewer flow:**
 - Network data provided by water companies and local authorities
- **(2D) Overland flow:**
 - LiDAR with 1m resolution
 - Buildings polygons
 - Land use – OSM
- **Rainfall-runoff - hydrological characterisation:**
 - Buildings polygons
 - Land use – OSM



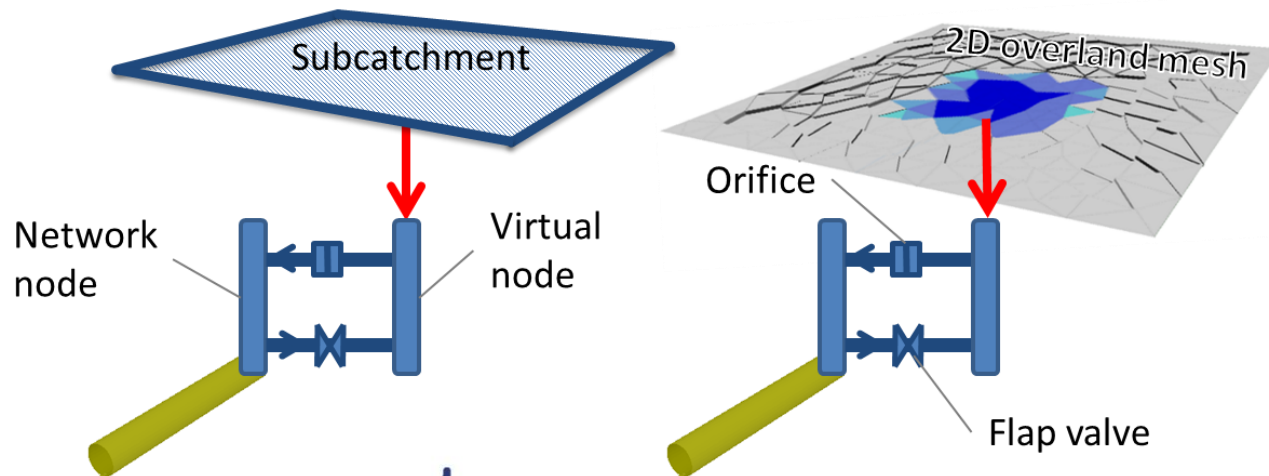
Model building – Hydrological characterisation



Model building – Connection between modules

“Standardisation” of connections between:

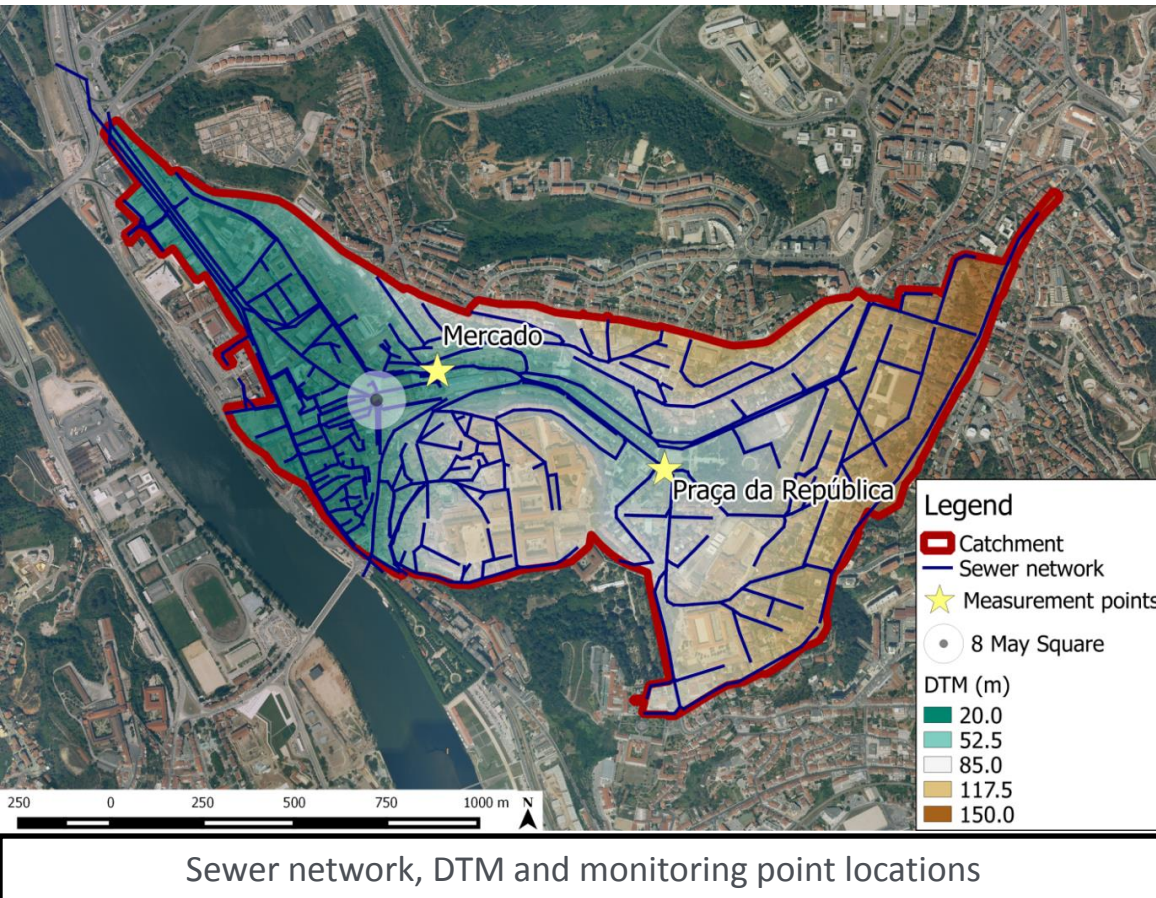
- Sub-catchments and sewer network, when water flows into the sewer system (SD models)
- 2D overland and sewer network (SD and FD models)



3. CASE STUDY



Coimbra, Portugal



Area: 1.5 km²

Average slope: 0.24 m/m

Sewer system:

- total length: 35.0 km
- combined system: 29.5 km
- waste water system: 4.1 km
- storm water system: 1.4 km



Resolution of SD and FD models

- SD model – subcatchments' statistics:

- Number of subcatchments 911
- Maximum subcatchment size (m²) 47,978
- Minimum subcatchment size (m²) 8
- Average subcatchment size (m²) 1,727

- FD model – 2D overland mesh stats:

- Number of elements 10,741
- Maximum element size (m²) 678
- Minimum element size (m²) 25
- Average element size (m²) 88



4. RESULTS & DISCUSSION

- Model performance comparison
- Insights into model sensitivity to rainfall input resolution

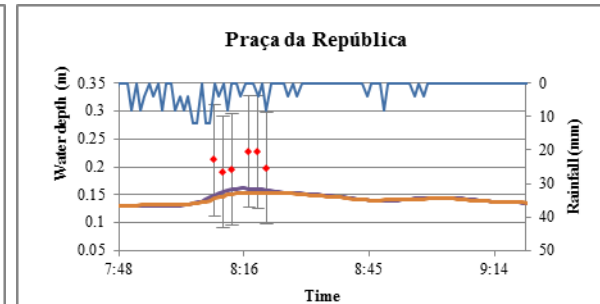
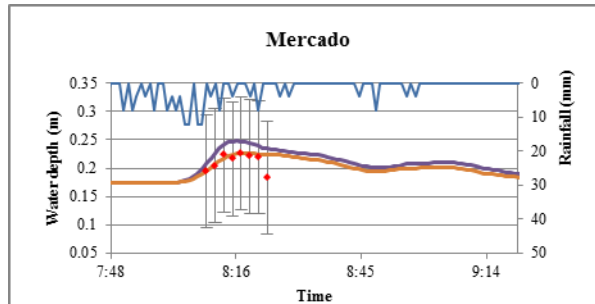


4.1 MODEL PERFORMANCE COMPARISON

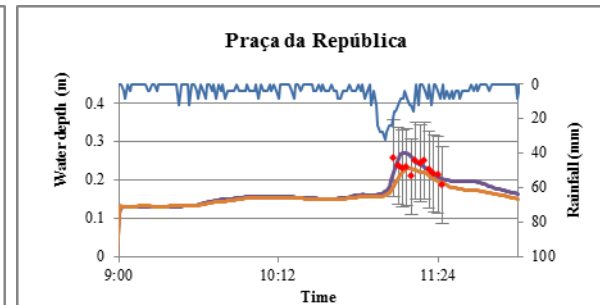
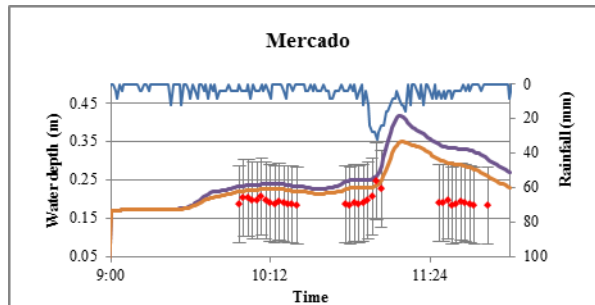


Simulated vs. observed water depths

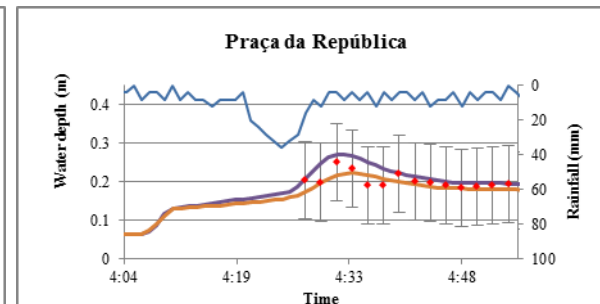
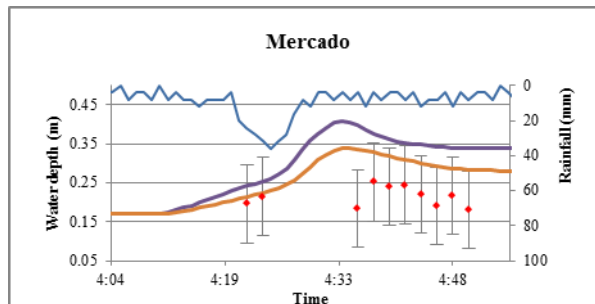
2011/01/29



2011/02/13



2011/02/16



● Observations (± 0.10 m)

— Rainfall

— SD

— FD

Runoff and flood volumes

Simulation	Model	Duration (min)	Total rainfall (mm)	Total runoff (m ³)	Max volume on the 2D surface (m ³) *
2011-01-29	SD	120	3	2289.7	1773.0
	FD	120	3	2483.0	2156.8
2011-02-13	SD	180	13	12843.0	8333.0
	FD	180	13	12170.4	9934.9
2011-02-16	SD	60	9	8879.3	6692.8
	FD	60	9	8093.8	7269.5

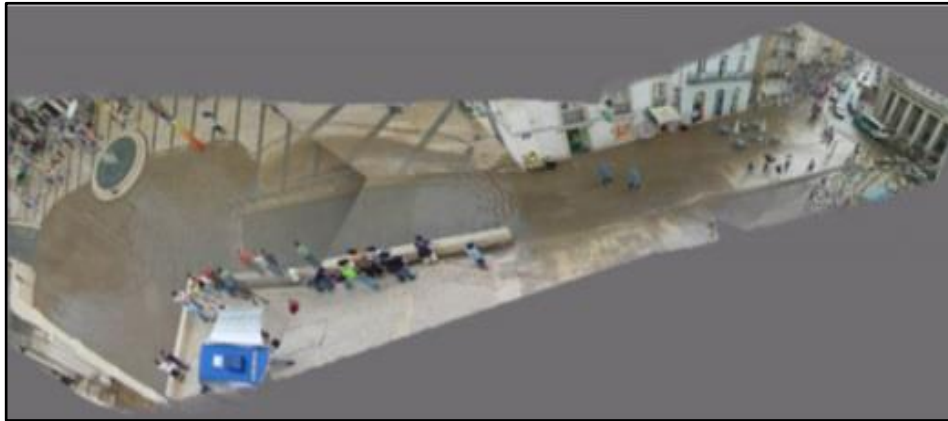
* Max volume on the 2D surface (m³): max flood volume registered on the overland surface mesh during simulations

- Volume on 2D surface is generally higher on the FD model
- Potential reason: runoff is trapped...



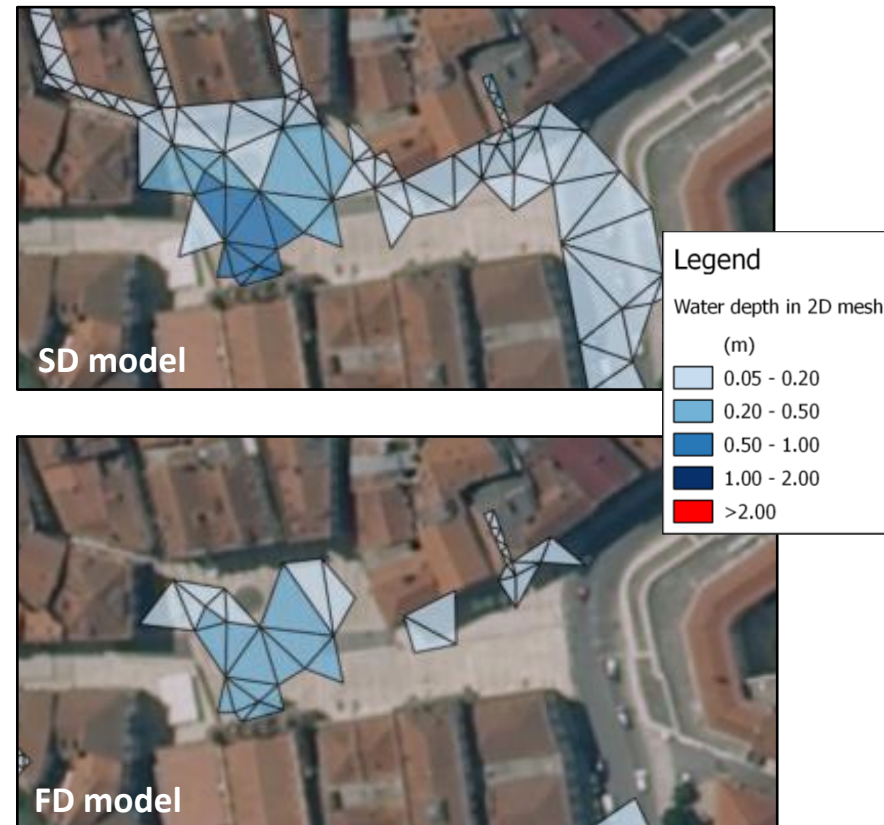
Observed vs. simulated flood extent

Flood event with photographic evidence,
2006/06/09 – Return period: 50 years



Simulated maximum volume on the 2D surface:

- SD: 26,933.5 m³
- FD: 29,808.1 m³



Results suggest...

MORE DETAILED MODELS REQUIRE MORE DETAILED AND BETTER QUALITY DATA (for implementation and calibration)!

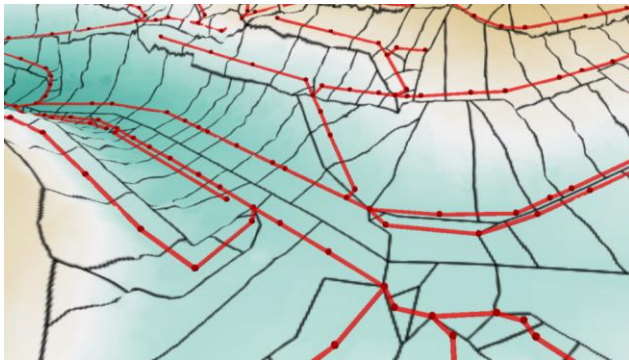
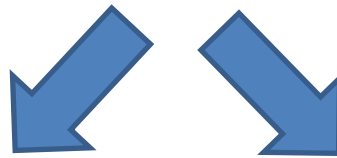
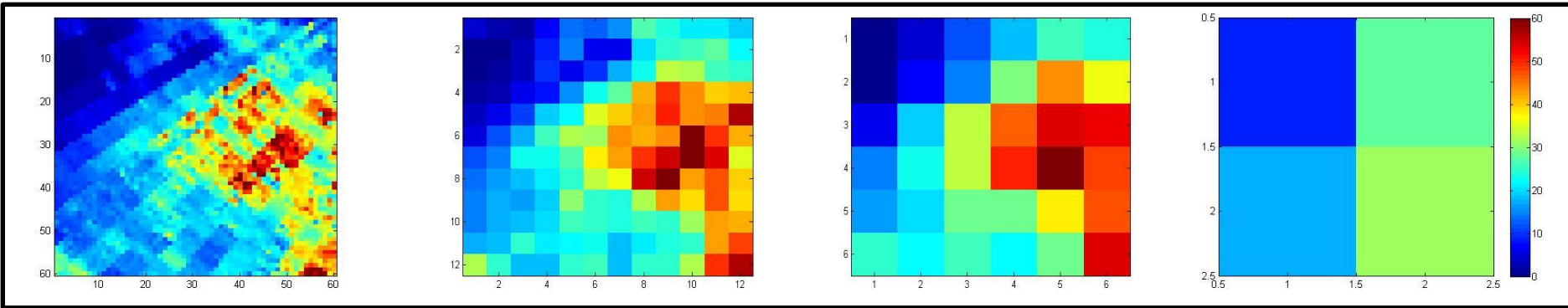
- Most sensible parameters for SD/FD models:
 - Hydrological characterisation
 - Capacity of the gullies
- Type of model (SD/FD) will depend:
 - Purpose
 - Quality of available data
- Combine SD with FD



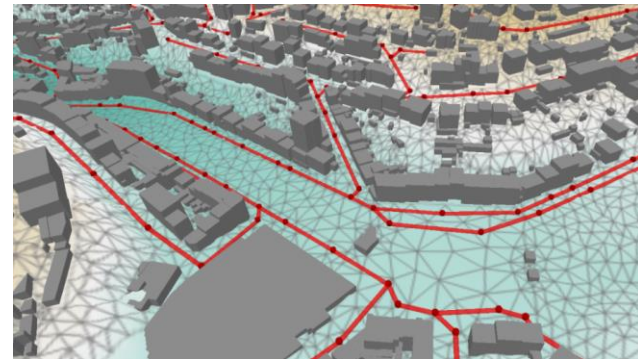
4.2 INSIGHTS INTO MODEL SENSITIVITY TO RAINFALL INPUT RESOLUTION



Radar data resolution comparison



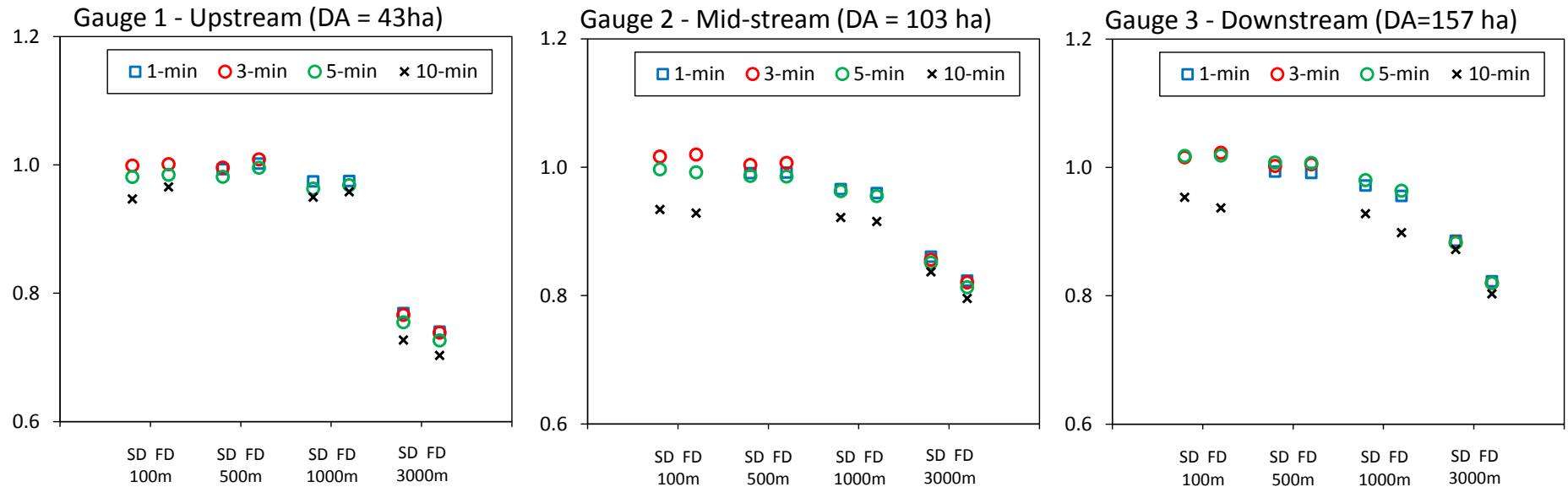
SD



FD



BIAS (100 m / 1 min as reference)



- As expected: bigger impact at smaller drainage areas
- Big drop at 3 km spatial resolution (RG?) and 10 min temporal resolution
- Temporal and spatial resolution are related: no use in having super high t resolution and coarse spatial resolution and viceversa
- In FD models: using coarser data means you're wasting high res rainfall (RG data for detailed models?) -> FD requires high res rainfall data



5. FUTURE WORK



Future work

- Further refinement and testing of FD models:
 - Gullies
 - Improved calibration (methodologies and data!)
 - Potential coupling with urban groundwater models



Future work – Cranbrook Catchment, UK

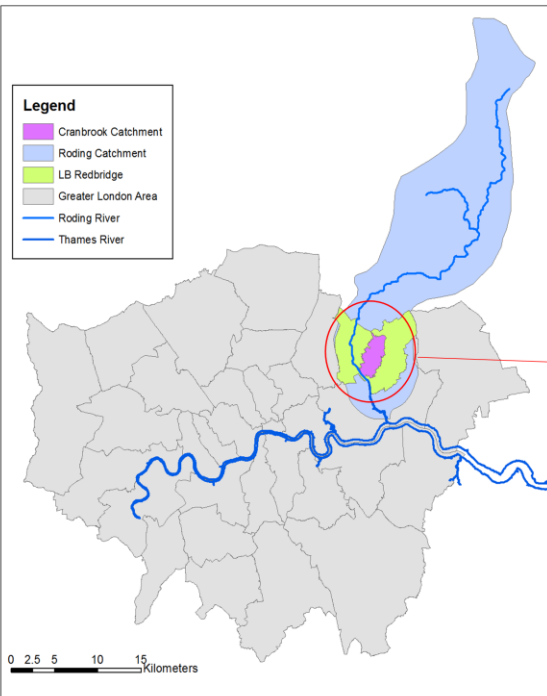


Figure 1: General location: North-East London

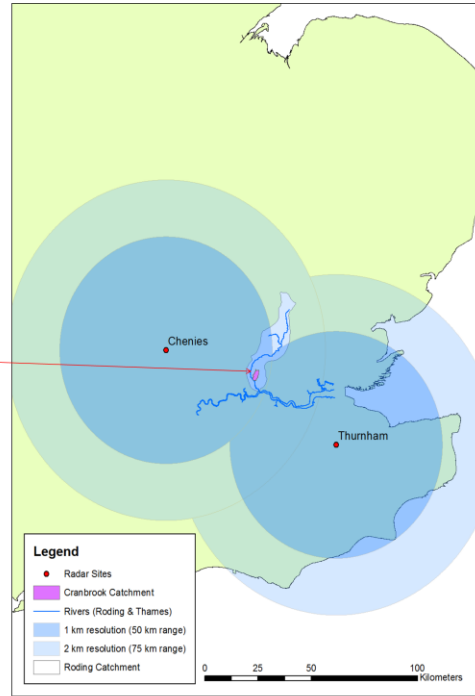
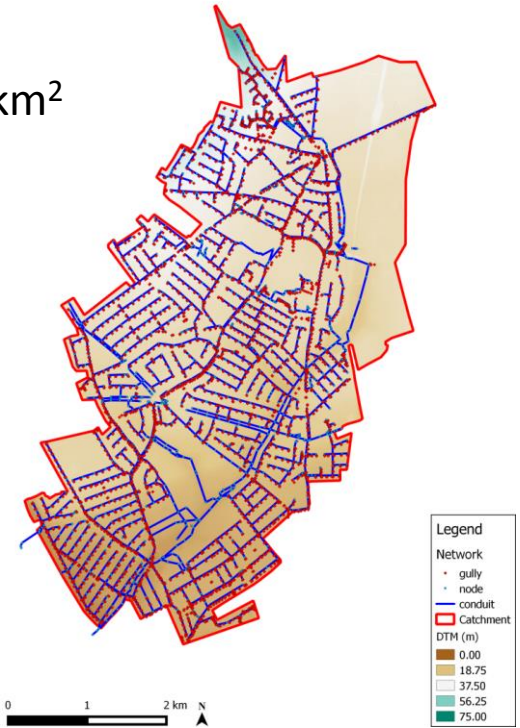
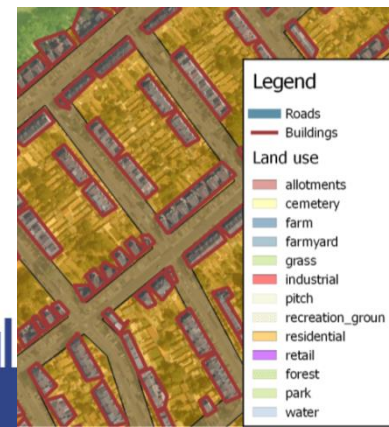
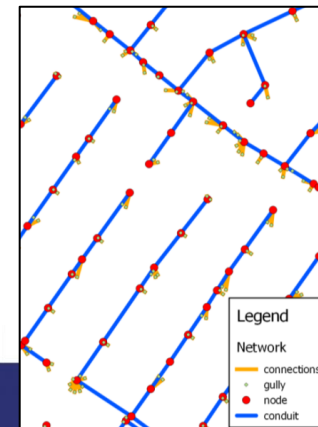


Figure 2: Radar Coverage

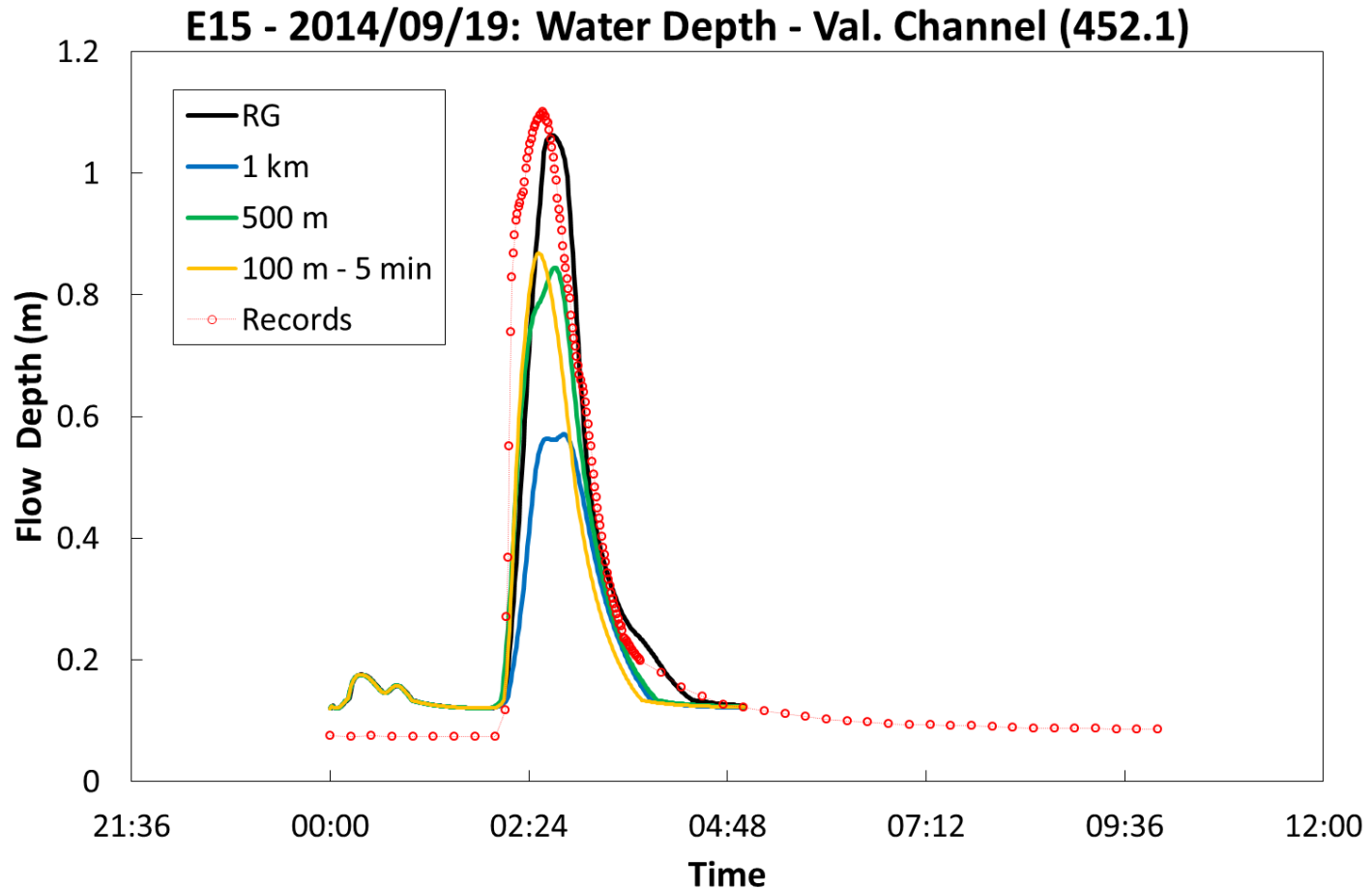
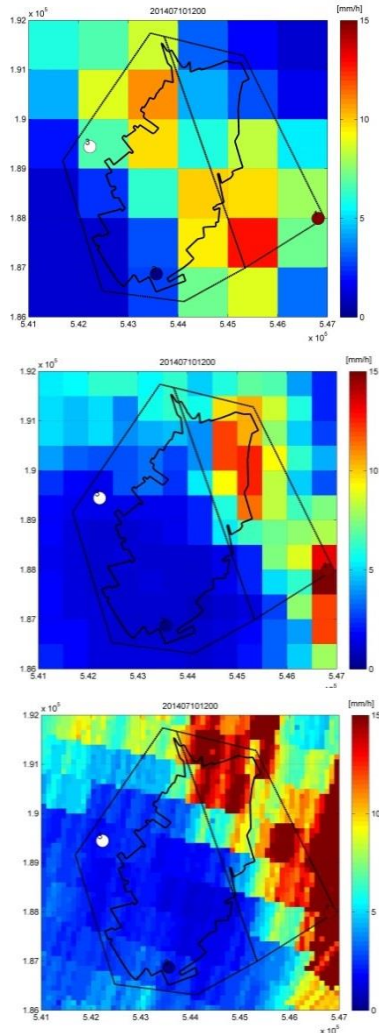
Area: 8.7 km²



Test of UKMO super-resolution product



Preliminary results

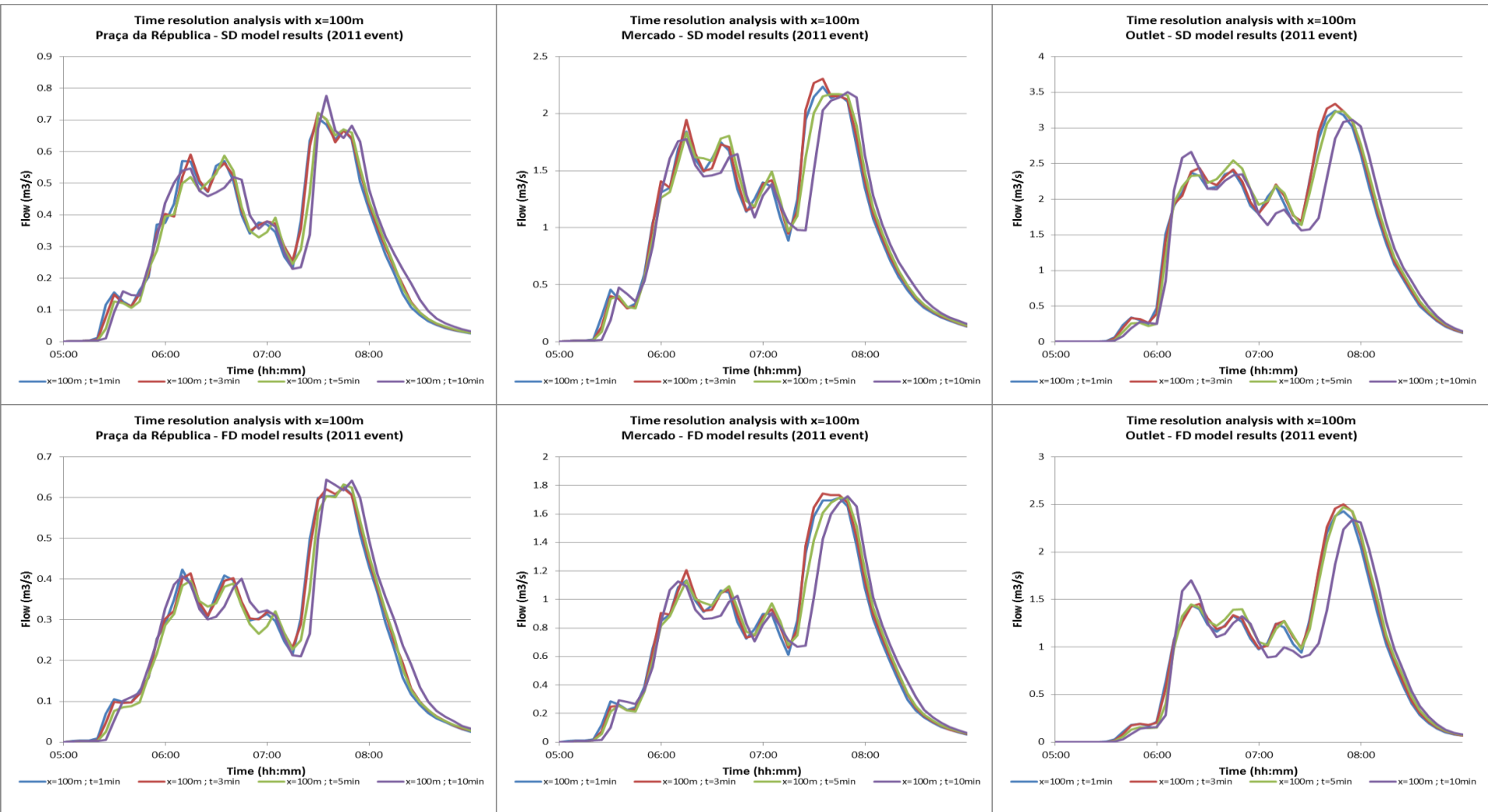


Thank you

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Event 1 – Temporal resolution comparison



Event 1 – Temporal resolution comparison

- SD model:

Table summary - RD of peak flow (time variation):

	x=100m ; t=1min	x=100m ; t=3min	x=100m ; t=5min	x=100m ; t=10min
Praça da República	0%	-2%	-2%	-10%
Mercado	0%	-2%	-1%	1%
Outlet	0%	-3%	0%	4%

Table summary - RD of volume (time variation):

	x=100m ; t=1min	x=100m ; t=3min	x=100m ; t=5min	x=100m ; t=10min
Praça da República	0%	-1%	2%	-2%
Mercado	0%	-2%	-1%	1%
Outlet	0%	-2%	-2%	2%

- FD model:

Table summary - RD of peak flow (time variation):

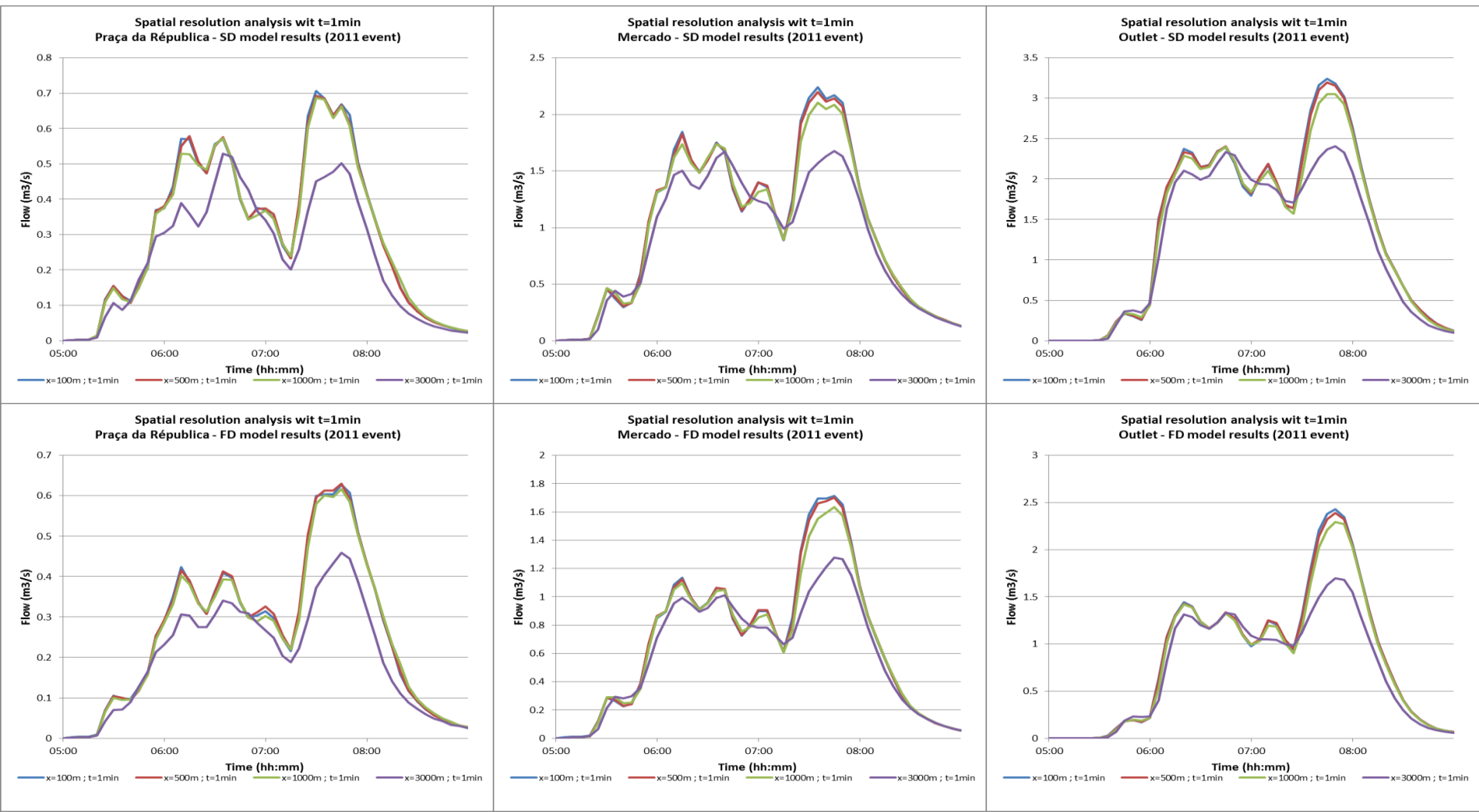
	x=100m ; t=1min	x=100m ; t=3min	x=100m ; t=5min	x=100m ; t=10min
Praça da República	0%	1%	-1%	-3%
Mercado	0%	-2%	-1%	1%
Outlet	0%	-3%	-2%	4%

Table summary - RD of volume (time variation):

	x=100m ; t=1min	x=100m ; t=3min	x=100m ; t=5min	x=100m ; t=10min
Praça da República	0%	-1%	2%	-2%
Mercado	0%	-2%	0%	2%
Outlet	0%	-2%	-2%	4%



Event 1 – Spatial resolution comparison



Event 1 – Spatial resolution comparison

- SD model:

Table summary - RD of peak flow (space variation):

	x=100m ; t=1min	x=500m ; t=1min	x=1000m ; t=1min	x=3000m ; t=1min
Resolution				
Praça da República	0%	2%	3%	25%
Mercado	0%	2%	2%	22%
Outlet	0%	1%	6%	26%

Table summary - RD of volume (space variation):

	x=100m ; t=1min	x=500m ; t=1min	x=1000m ; t=1min	x=3000m ; t=1min
Resolution				
Praça da República	0%	0%	2%	22%
Mercado	0%	0%	2%	12%
Outlet	0%	1%	3%	13%

- FD model:

Table summary - RD of peak flow (space variation):

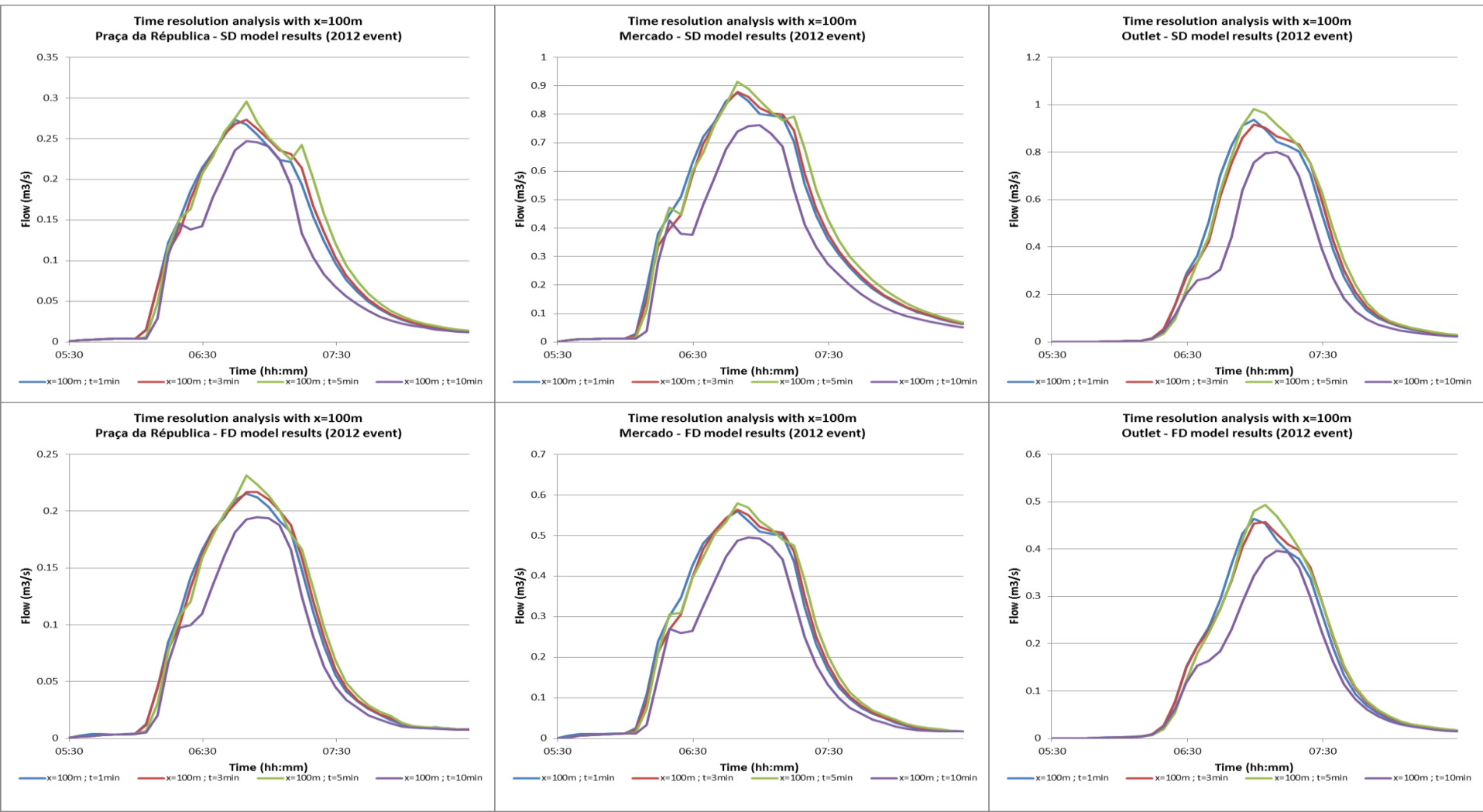
	x=100m ; t=1min	x=500m ; t=1min	x=1000m ; t=1min	x=3000m ; t=1min
Resolution				
Praça da República	0%	0%	2%	27%
Mercado	0%	1%	1%	23%
Outlet	0%	2%	5%	30%

Table summary - RD of volume (space variation):

	x=100m ; t=1min	x=500m ; t=1min	x=1000m ; t=1min	x=3000m ; t=1min
Resolution				
Praça da República	0%	0%	1%	23%
Mercado	0%	0%	3%	14%
Outlet	0%	1%	3%	16%



Event 2 – Temporal resolution comparison



Event 2 – Temporal resolution comparison

- SD model:

Table summary - RD of peak flow (time variation):

Resolution	x=100m ; t=1min	x=100m ; t=3min	x=100m ; t=5min	x=100m ; t=10min
Praça da República	0%	0%	-8%	10%
Mercado	0%	-2%	-1%	1%
Outlet	0%	2%	-5%	15%

Table summary - RD of volume (time variation):

Resolution	x=100m ; t=1min	x=100m ; t=3min	x=100m ; t=5min	x=100m ; t=10min
Praça da República	0%	-2%	-6%	17%
Mercado	0%	0%	-4%	21%
Outlet	0%	0%	-3%	25%

- FD model:

Table summary - RD of peak flow (time variation):

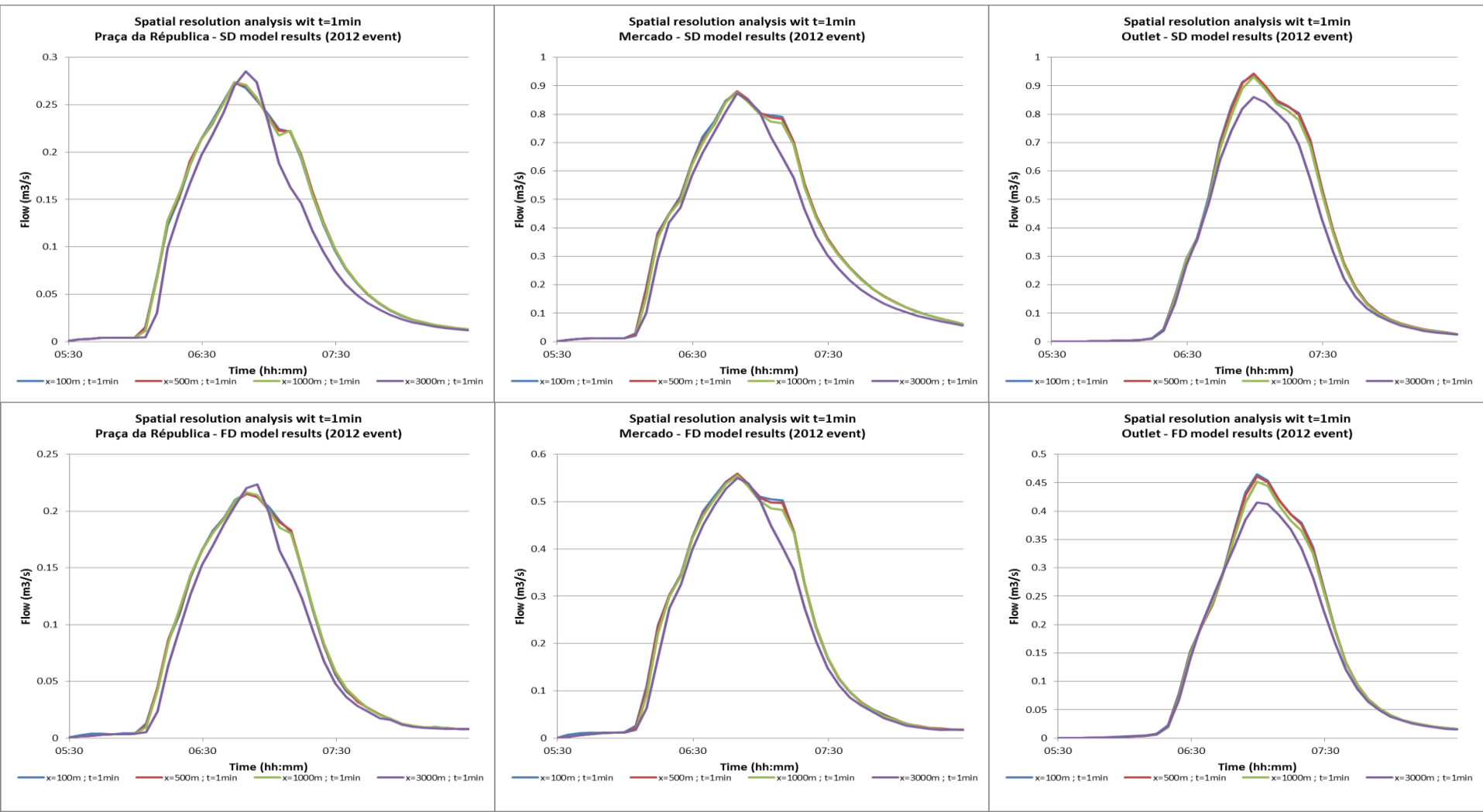
Resolution	x=100m ; t=1min	x=100m ; t=3min	x=100m ; t=5min	x=100m ; t=10min
Praça da República	0%	-1%	-7%	10%
Mercado	0%	-2%	-1%	1%
Outlet	0%	2%	-6%	15%

Table summary - RD of volume (time variation):

Resolution	x=100m ; t=1min	x=100m ; t=3min	x=100m ; t=5min	x=100m ; t=10min
Praça da República	0%	-1%	-3%	16%
Mercado	0%	0%	-2%	19%
Outlet	0%	-1%	-3%	18%



Event 2 – Spatial resolution comparison



Event 1 – Spatial resolution comparison

- SD model:

Table summary - RD of peak flow (space variation):

Resolution	x=100m ; t=1min	x=500m ; t=1min	x=1000m ; t=1min	x=3000m ; t=1min
Praça da República	0%	0%	0%	-4%
Mercado	0%	-1%	0%	11%
Outlet	0%	0%	1%	8%

Table summary - RD of volume (space variation):

Resolution	x=100m ; t=1min	x=500m ; t=1min	x=1000m ; t=1min	x=3000m ; t=1min
Praça da República	0%	0%	0%	11%
Mercado	0%	0%	2%	10%
Outlet	0%	1%	2%	10%

- FD model:

Table summary - RD of peak flow (space variation):

Resolution	x=100m ; t=1min	x=500m ; t=1min	x=1000m ; t=1min	x=3000m ; t=1min
Praça da República	0%	0%	0%	-4%
Mercado	0%	0%	0%	9%
Outlet	0%	1%	3%	11%

Table summary - RD of volume (space variation):

Resolution	x=100m ; t=1min	x=500m ; t=1min	x=1000m ; t=1min	x=3000m ; t=1min
Praça da República	0%	0%	0%	9%
Mercado	0%	1%	2%	9%
Outlet	0%	1%	2%	8%

