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Modeling runoff from a green roof

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Outline

- Motivation
- Objectives
- Theoretical background
- Experimental set-up
- Results
- Conclusions

Motivation

- **Urban centers: need for sustainable technologies managing runoff**
- **Odense: more than 35 overflows per year**

There is a need for modeling tools, able to reproduce green roof runoff

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Objectives

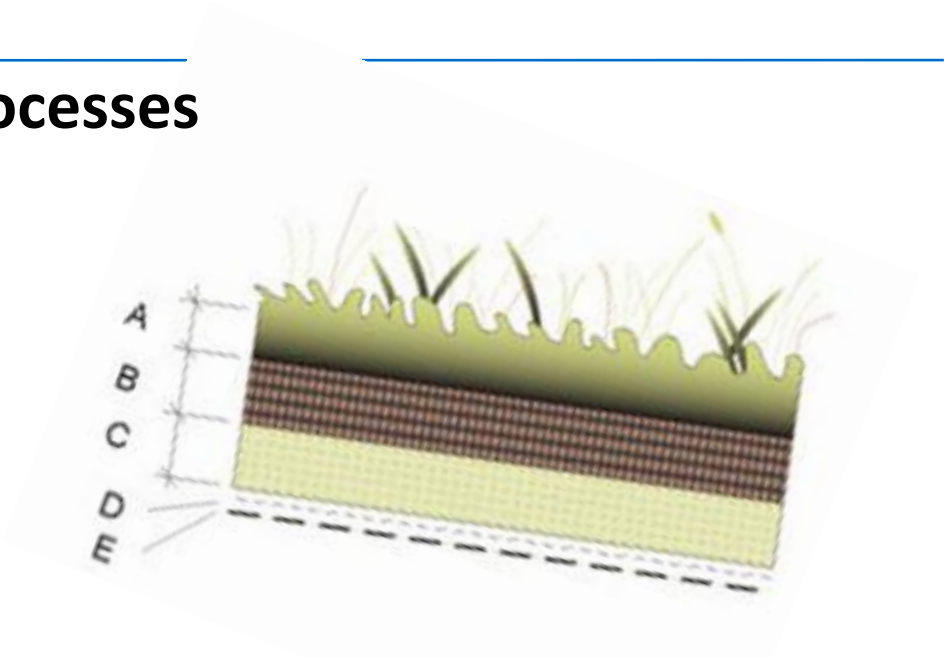
1. Develop and build a mathematical model, able to reproduce rainfall-runoff relationships.

2. Test the model on field data.

3. Examine the impact of green roofs on runoff hydrographs with respect to rainfall depth and initial condition.

Theoretical Background

Identification of dominant processes



Processes:

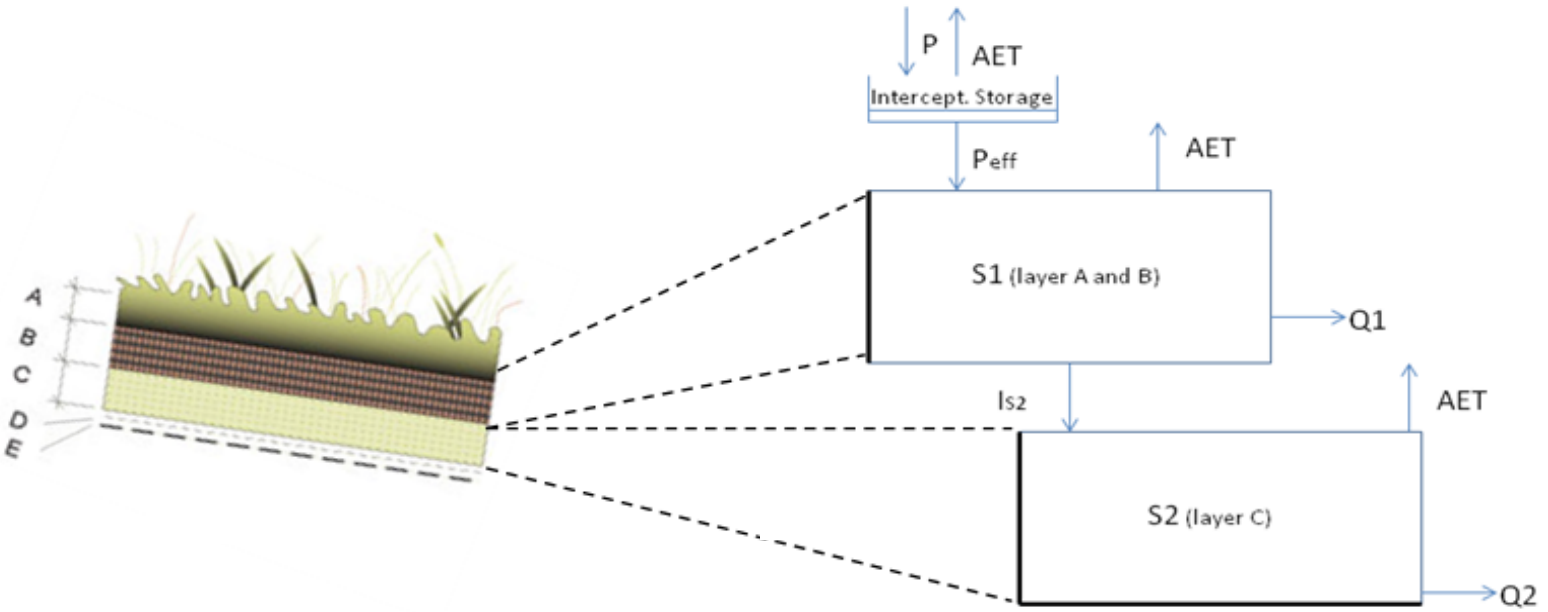
- Rainfall (P)
- Interception (I)
- Infiltration
- Subsurface flow - subsurface runoff (SSF)
- Evapotranspiration (AET)
- Saturated surface flow – surface runoff (SF)

Layering:

A. 30mm Sedum-herb-grass had
B. 30 mm Roof soil
C. 40 mm Mineral Wool
D. 0.8mm Root barrier foil
E. Roof

Theoretical Background

Conceptual model – 2 reservoir model

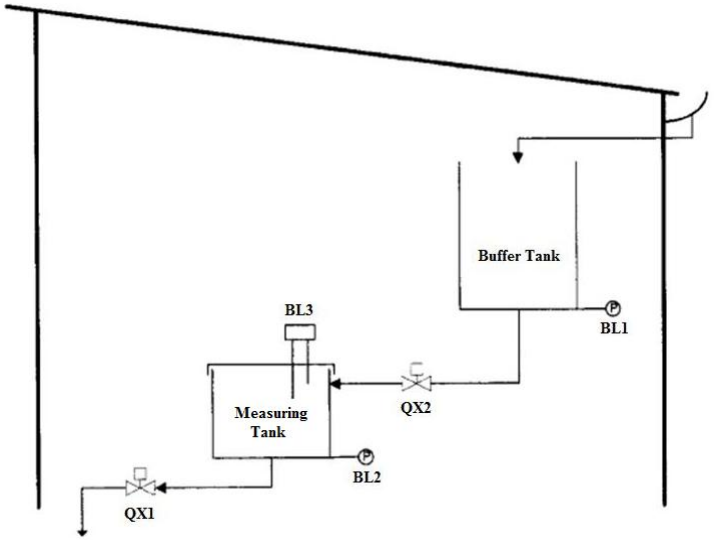


Experimental Set-up

Study Period:
April 2009- June 2010

Recorded data:
- Rainfall
- Runoff
- Soil moisture

Measuring devices:
- BL1: Level meter
- BL2: Level meter
- BL3: Level electrode
- QX2: Filling valve
- QX1: Drain valve
- 2 soil moisture sensors



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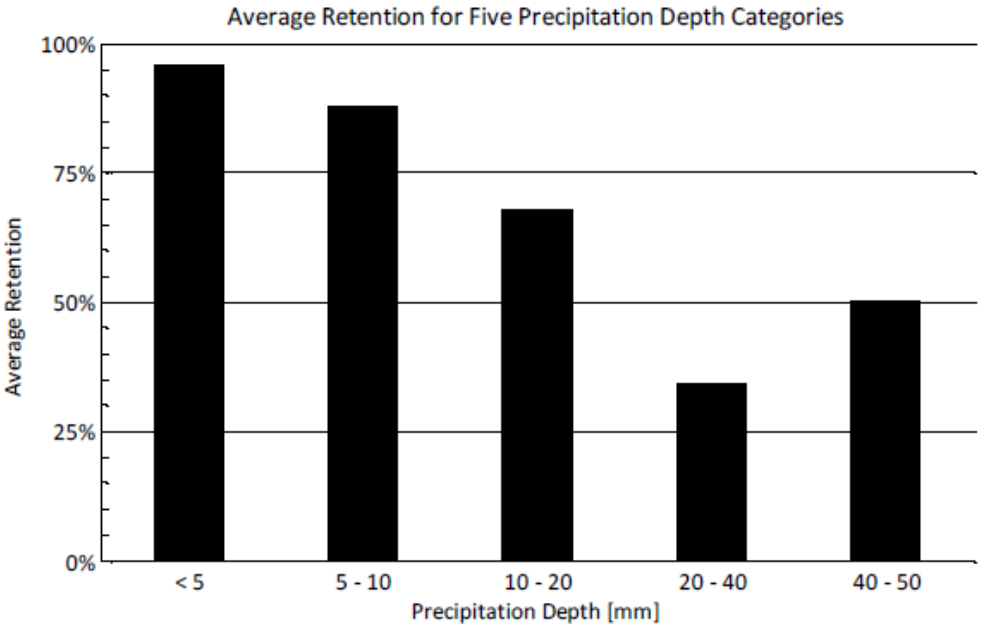
Results

- **Experimental Results**
- **Modeling Results**

Experimental Results

Retention capacity

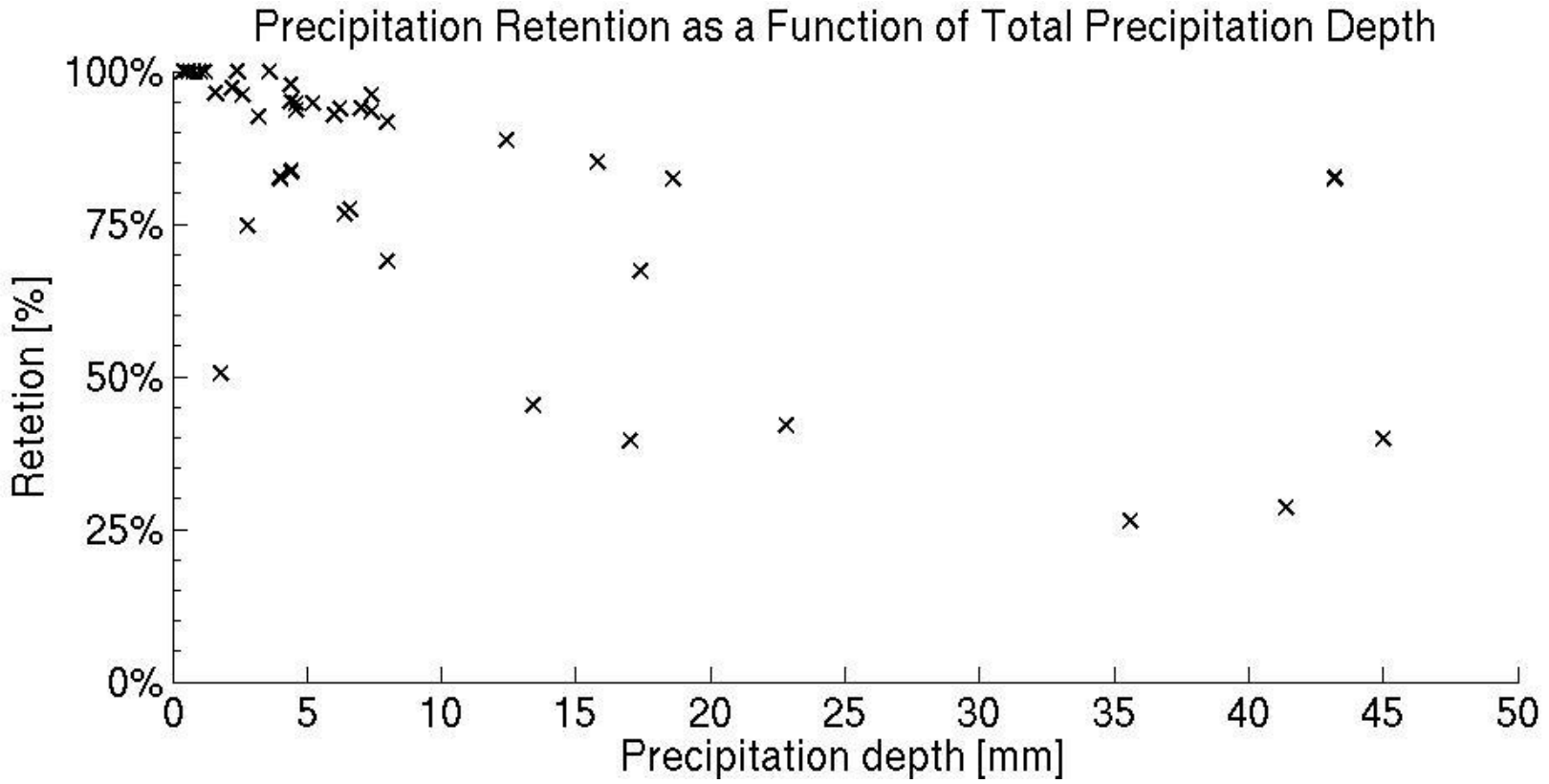
Total analyzed rainfall- runoff samples= 56



	Precipitation Depth Category				
	< 5mm	5 – 10mm	10 – 20mm	20 – 40mm	40 – 50mm
Average retention capacity in percent	95.85%	87.93%	68%	34.1%	50.3%
Standard deviation	9.8%	9.78%	21.25%	11%	28.4%
Percentage of total sample size	62.5%	17.8%	10.7%	3.3%	5.7%
Number of samples	35	10	6	2	3

Experimental results

Retention capacity of the green roof



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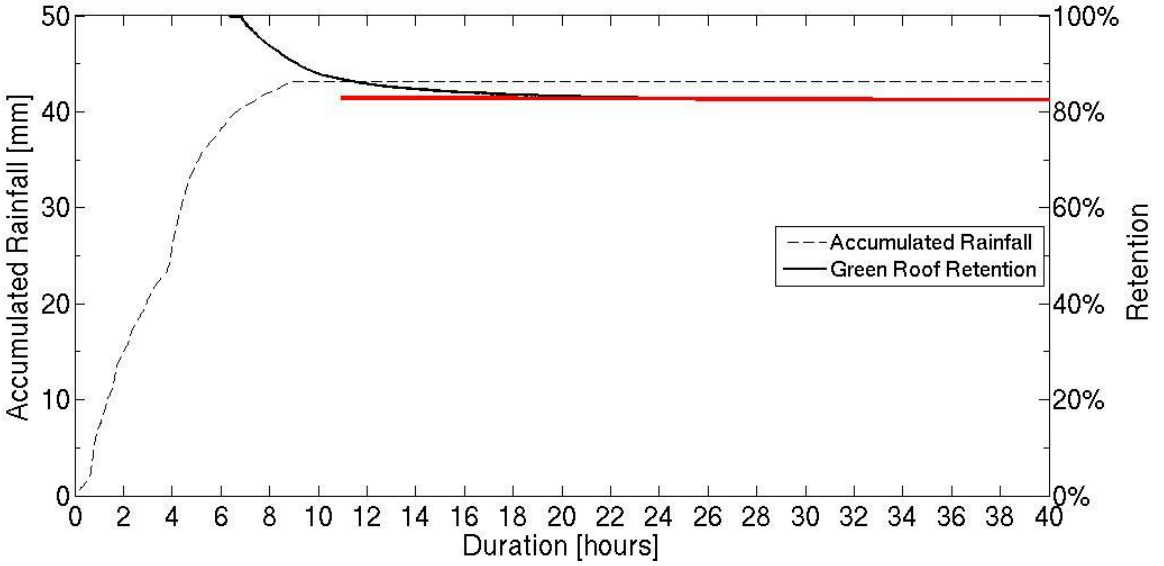
Experimental results

Detention, runoff and retention

Initially: Dry

Total Rainfall 43.2mm

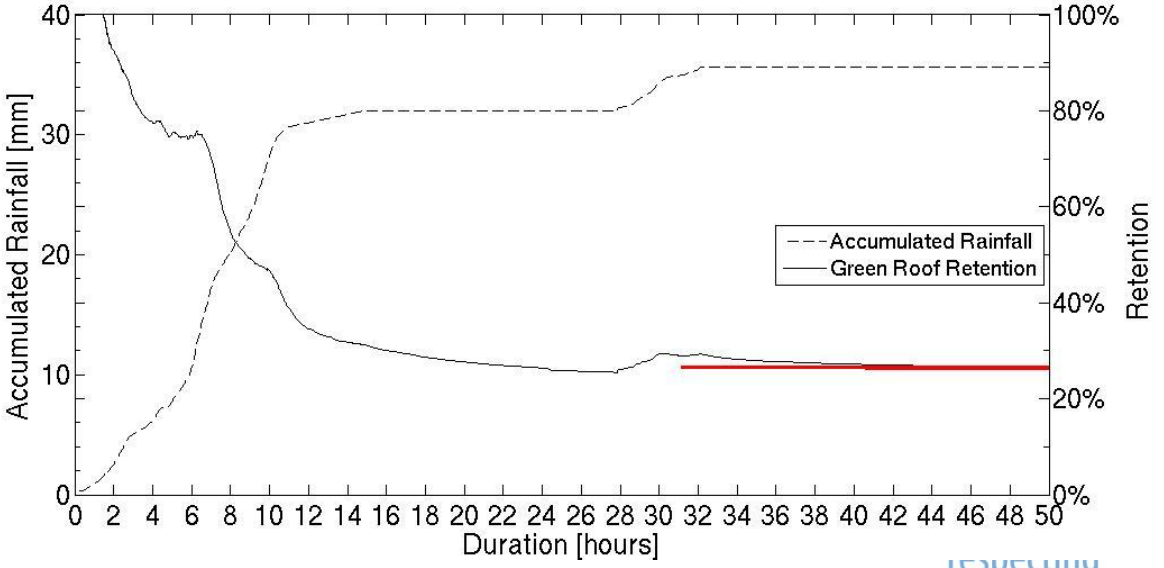
7th of June 2010



Initially: Wet

Total Rainfall 35.6mm

11-12th June 2009



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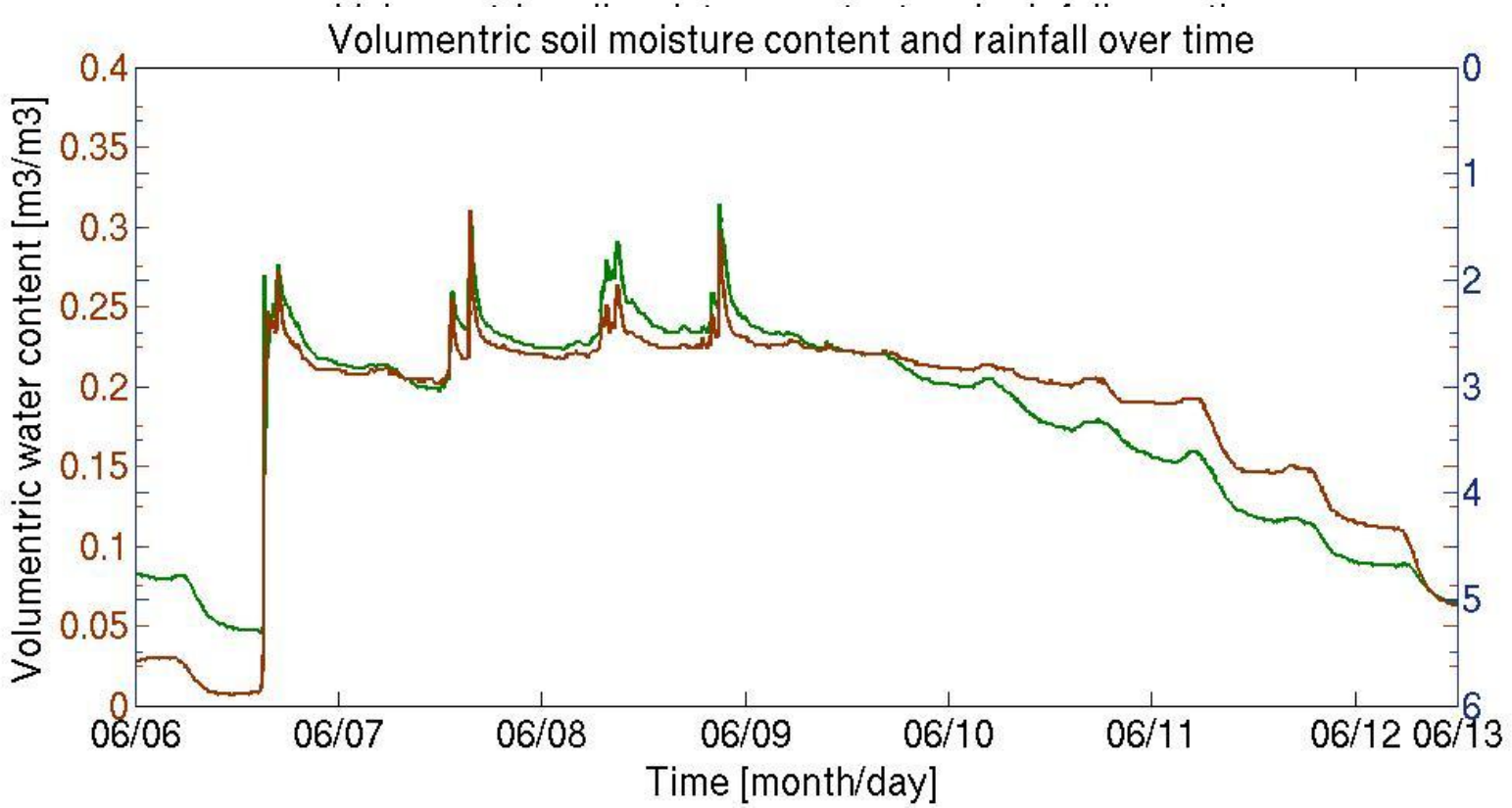
Experimental results

Dominant flow dynamics

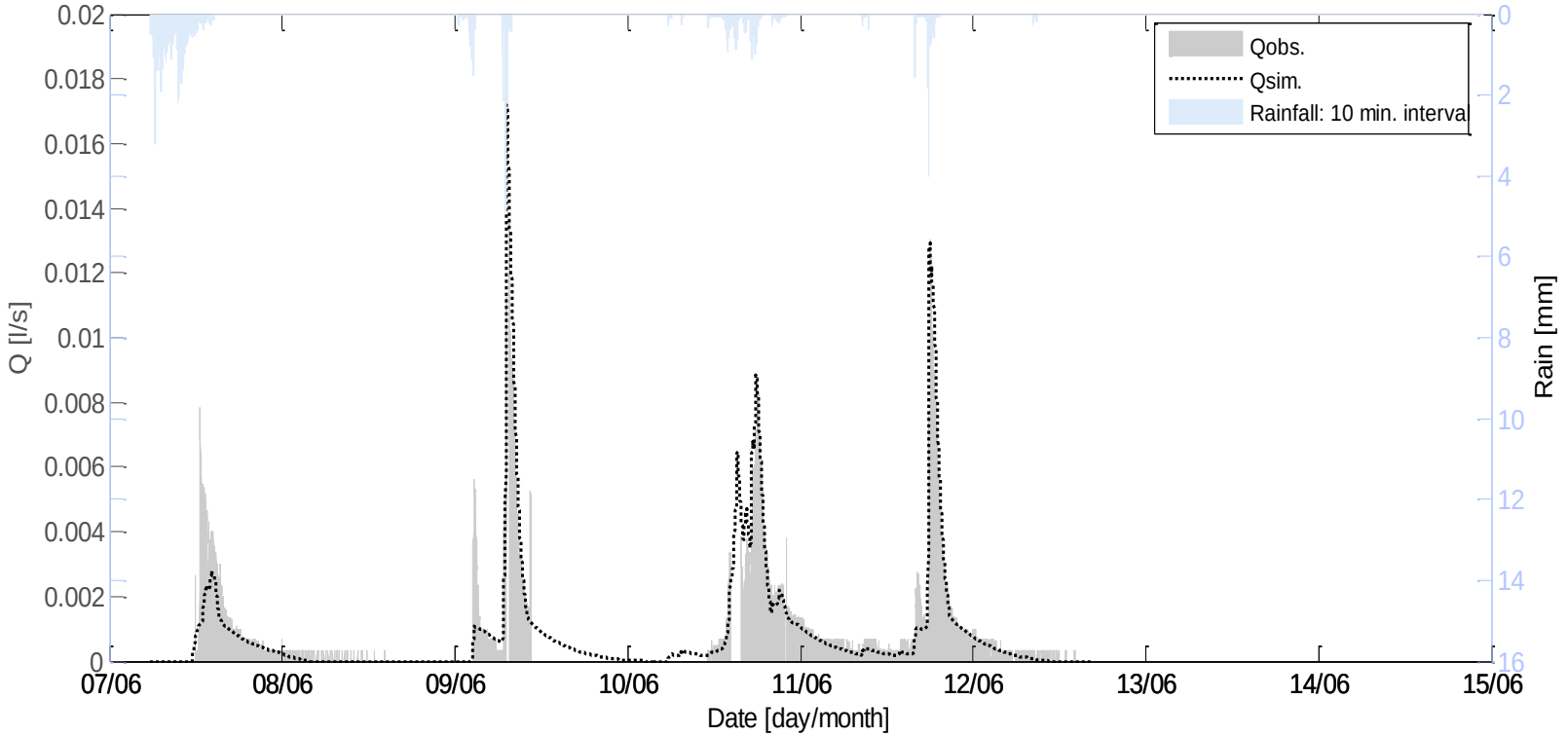


- **Surface flow does not occur on the roof, since moisture peaks in the soil layer are well defined by one data point and do not stay constant.**

Experimental results

Calibration

Total amount of rainfall: 91mm



- Total volume error: 1.78%
- Nash-Sutcliffe coefficient: 0.44
- General impression: model overestimates runoff
- Underestimates peak flows

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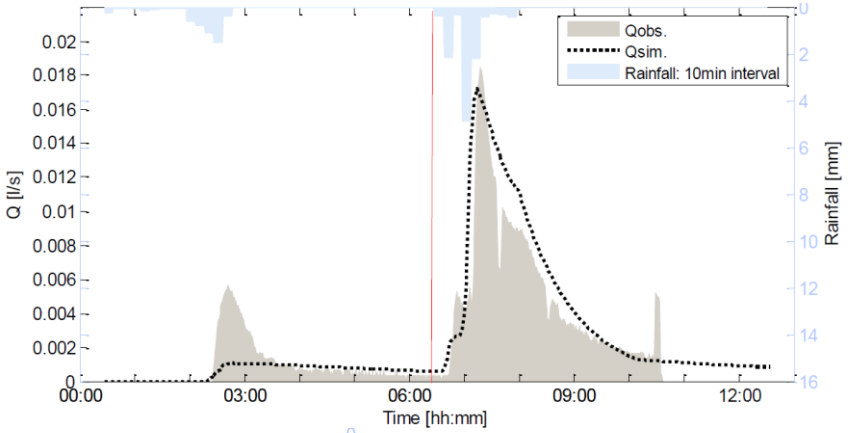
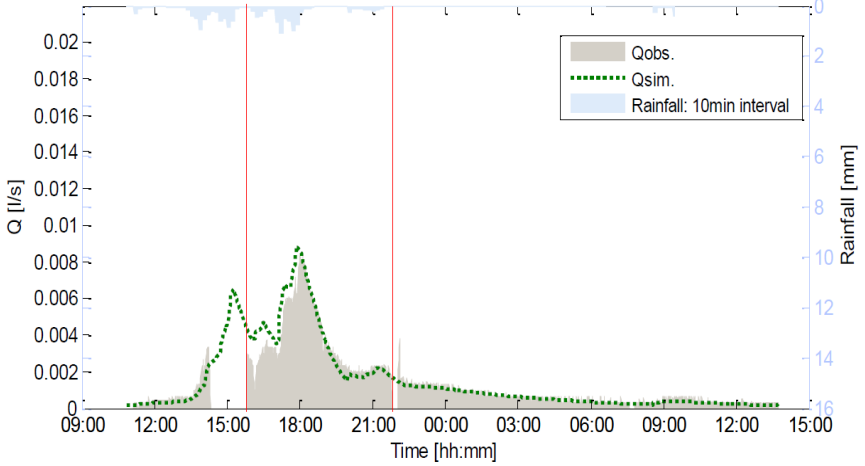
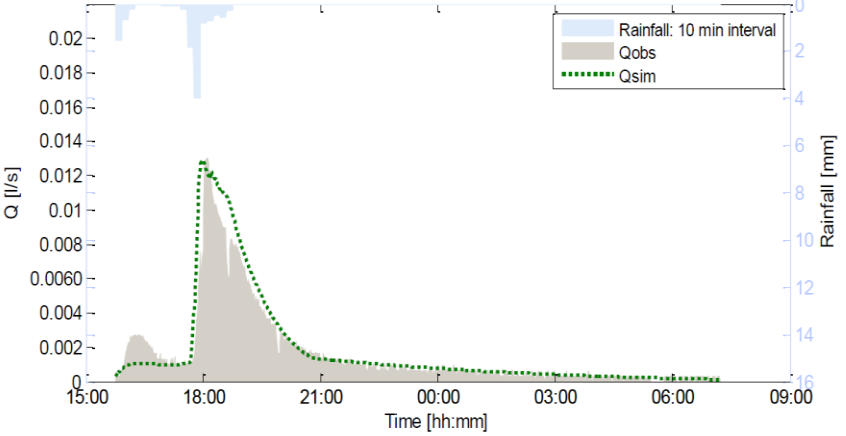
Modeling Results





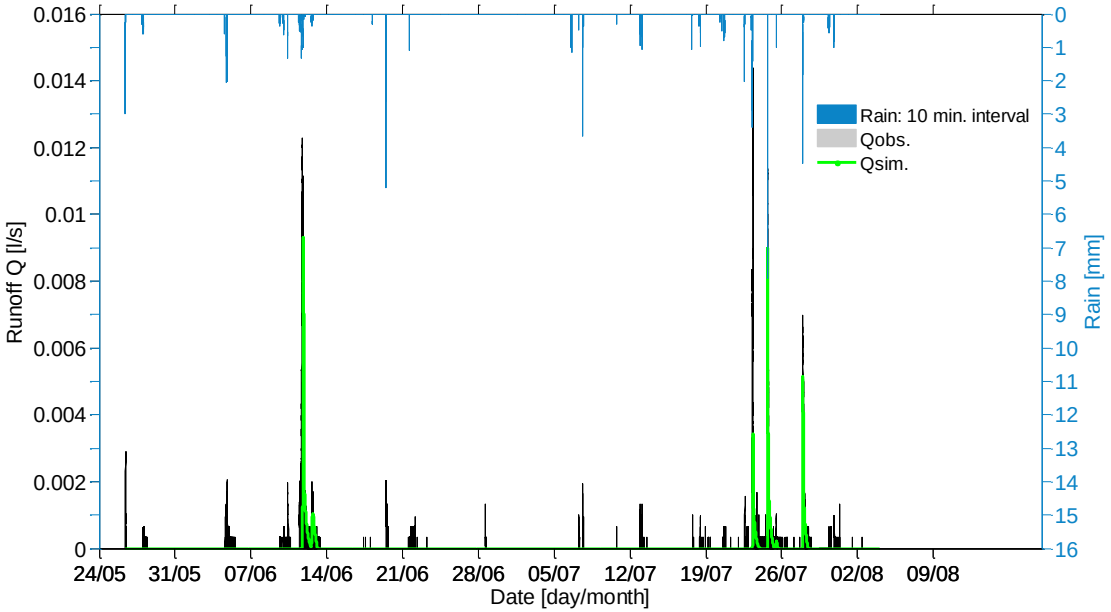


- Volume errors: -32.68% to 21%
- Peak flow errors: 1.21% to -81.03%
- Nash- Sutcliffe: 0.23 to 0.91
  -> 3/5 higher than 0.8.

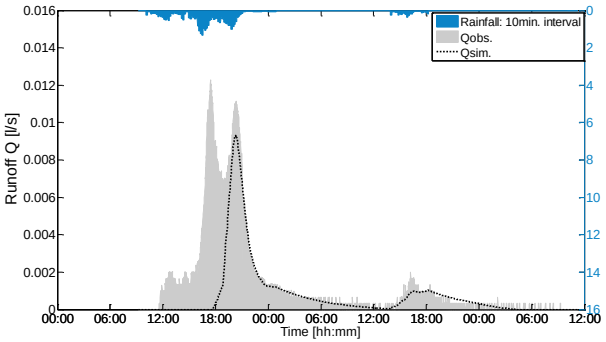
-> Timing and drainage behaviour: very well reproduced

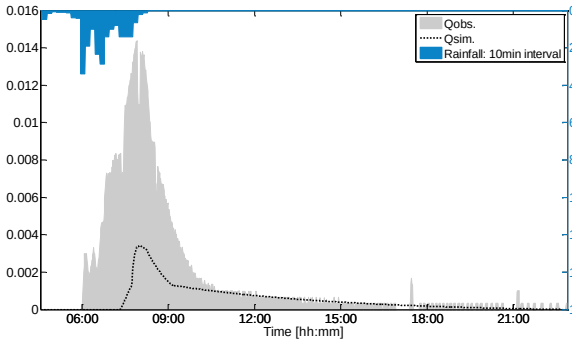
Modeling Results

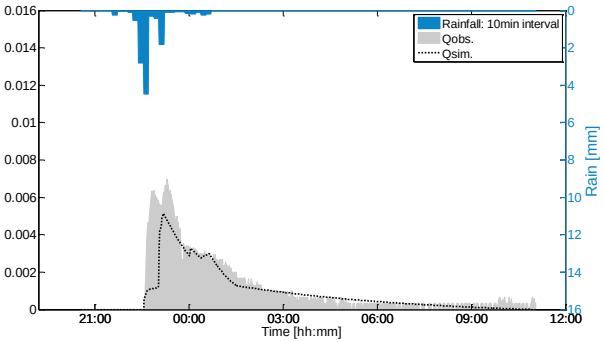
Model validation: 69 days – 34 rain events



- Total volume error: -49.81%







- Volume errors: -69.4% to 19.54%
- Peak flow errors: -76% to 16.52%

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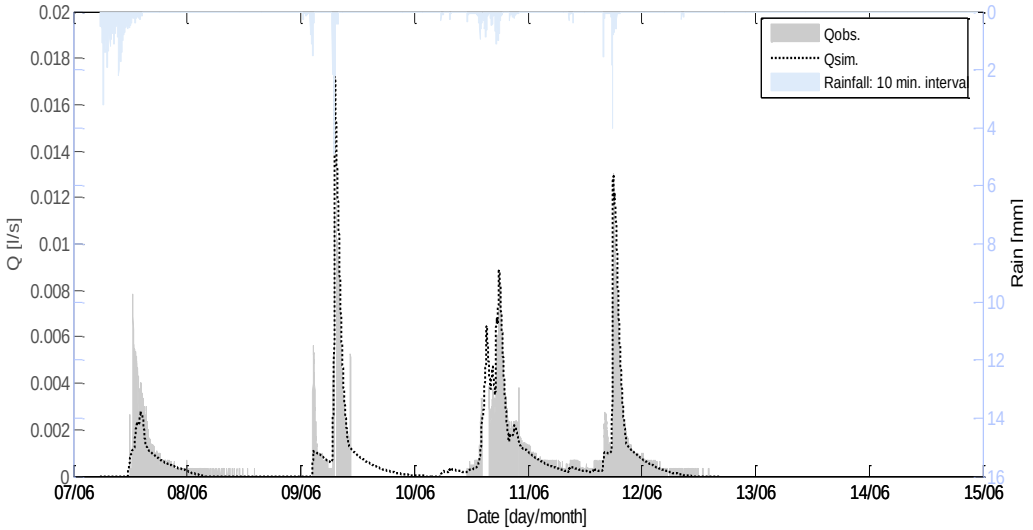
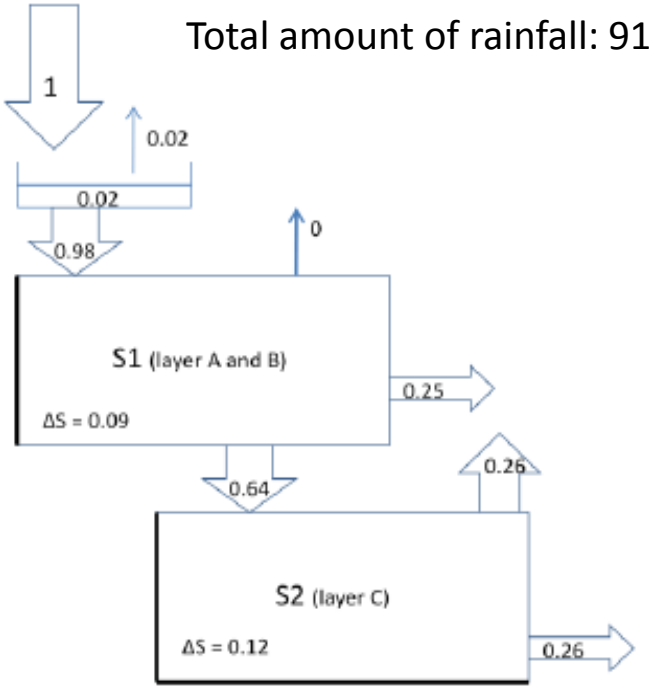
Conclusions



Total amount of rainfall: 91mm



- Substantial amount of rainfall is stored and evaporated
- Layer saturation is the key factor determining retention capacity
- A 2 storage linear reservoir model is a promising approach to simulate green roof runoff!

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THANK YOU FOR YOUR ATTENTION!

Photo via Inhabitat

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