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A simplified methodology for flood simulation in urban catchments

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Urban flooding

- Great importance due to urbanisation
- Integrated Catchment Modelling
- Physically-based models
  - computationally expensive
- Simplifications
  - hybrid models coupling detailed and conceptual models

The hybrid method

- Step 1
  – derivation of Unit Hydrograph of the catchment using a 2D hydrodynamic model
- Step 2
  – calculation of the losses in order to define the effective rainfall
- Step 3
  – flood simulation based on the principle of superposition

Materials

- Case study
  - urban catchment in Athens (Kypseli)
- Step 1
  - FLOW-R2D model
- Step 2
  - SWMM software
- Step 3
  - synthetic rainfall is generated

FLOW-R2D model

- In-house hydrodynamic 2D Model
- 2D Shallow Water Equations
- Finite Difference Method
- Non-staggered, cell-centered grid
- Modified McCormack numerical scheme
  - artificial viscosity is added
- Wet/dry modelling
  - water depth threshold

SWMM software

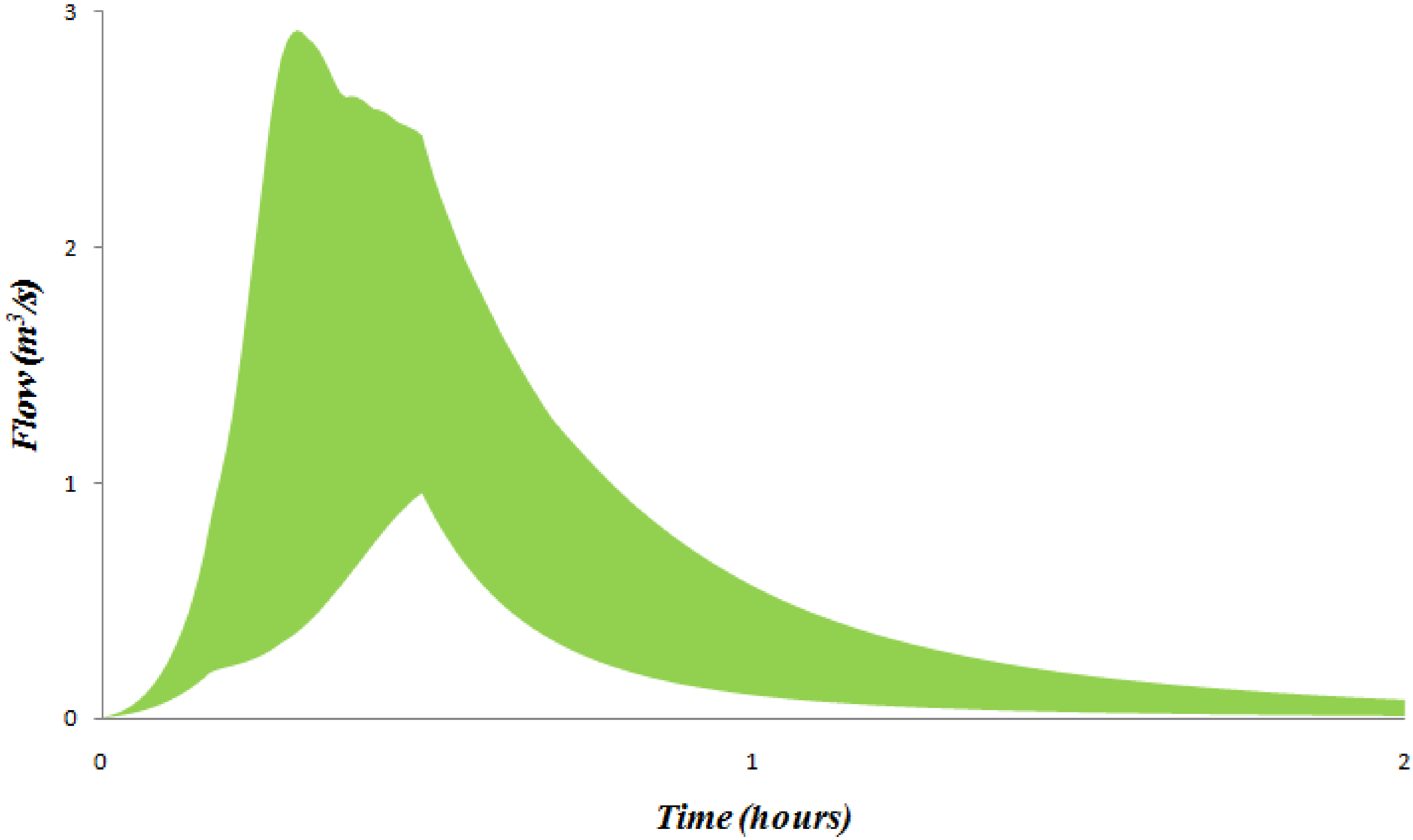
- Linkage of sub-models
- Rainfall-runoff model
  - kinematic wave equation
- Urban drainage model
  - 1D Shallow Water Equations
- Losses
  - initial abstraction
  - infiltration
  - runoff to the sewer network

Case study

Step 1

- FLOW-R2D parameters
  - grid size: 5 x 5 m
  - time step: 10^{-3} s
  - diffusion factor: 0.99
  - wet/dry threshold: 10^{-4} m
- 10-min Unit Hydrographs (100 runs)
  - Manning coefficient in urban zone: 0.02-0.05 $s/m^{1/3}$
  - Manning coefficient in urban open space zone: 0.03-0.08 $s/m^{1/3}$
- High Performance Computing (HPC)
  - cluster with 24 cores
  - each run requires 1 day of computational budget

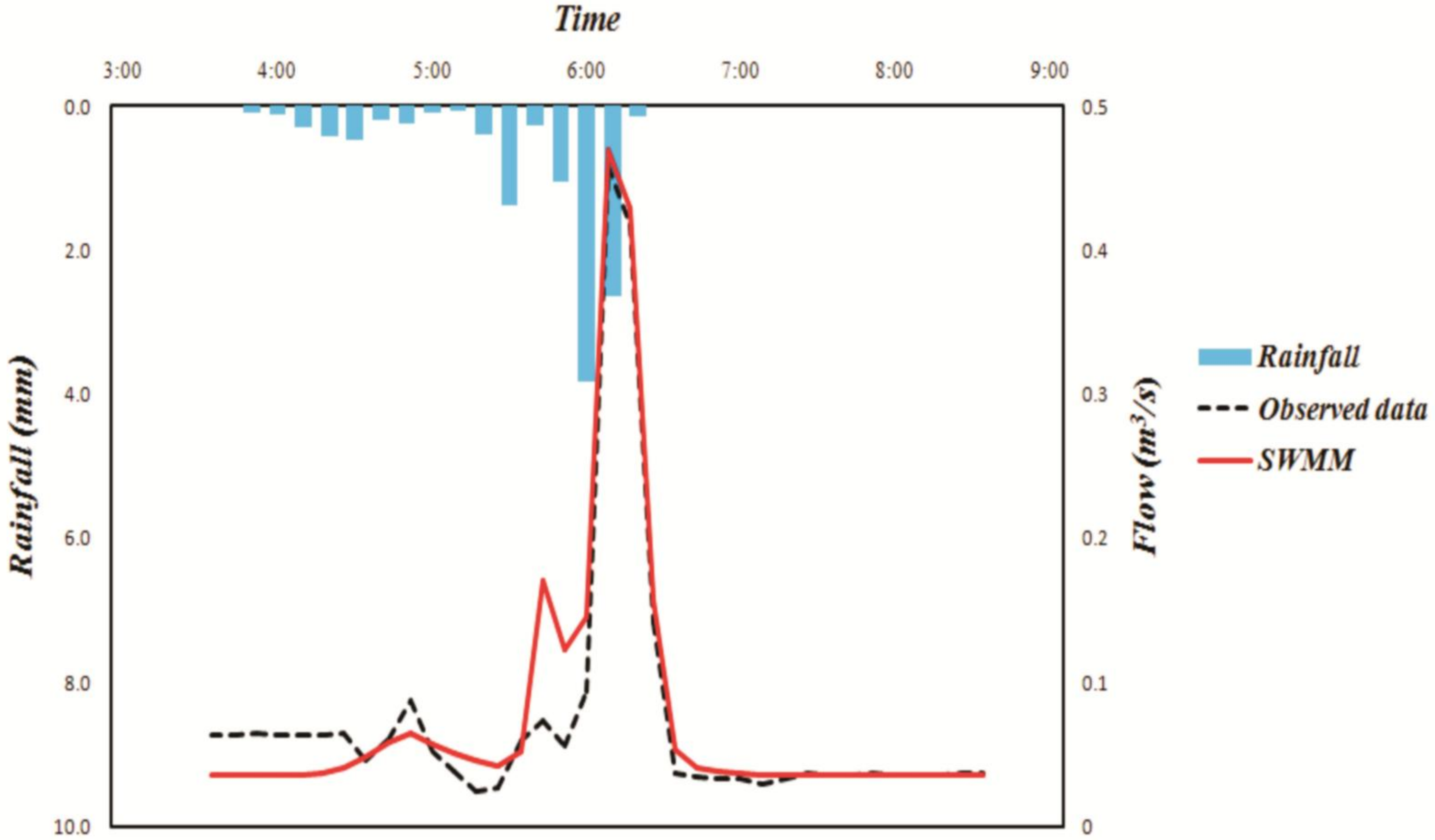
Ensemble of 100 UHs



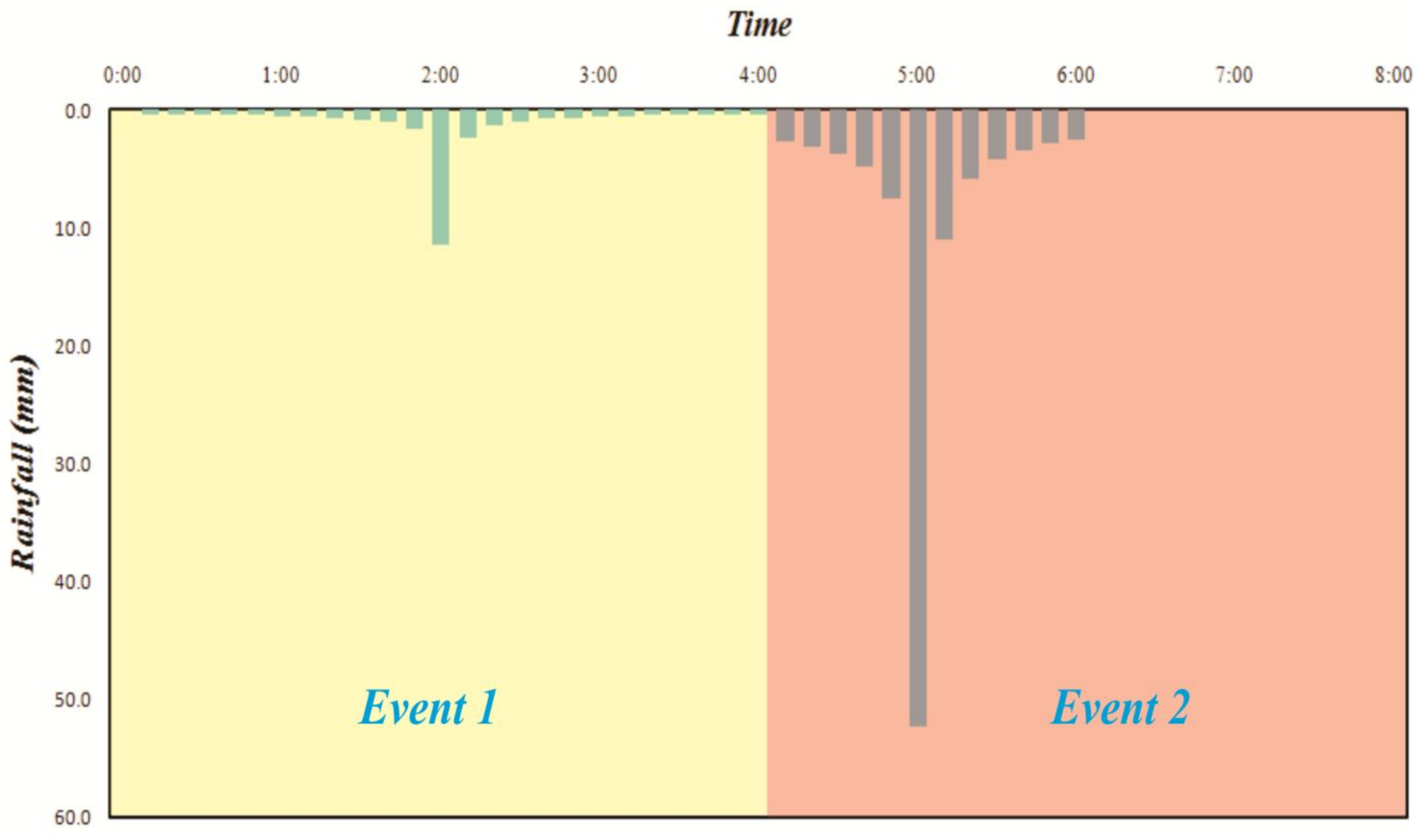
Step 2

- SWMM parameters calibrated (7 sub-catchments)
  - width: 82-918 m
  - impervious area: 13-77 %
  - impervious area Manning: 0.015 $s/m^{1/3}$
  - pervious area Manning : 0.200 $s/m^{1/3}$
  - impervious area initial abstraction: 2.54 mm
  - pervious area initial abstraction: 6.51 mm
  - sewer system Manning: 0.013 $s/m^{1/3}$

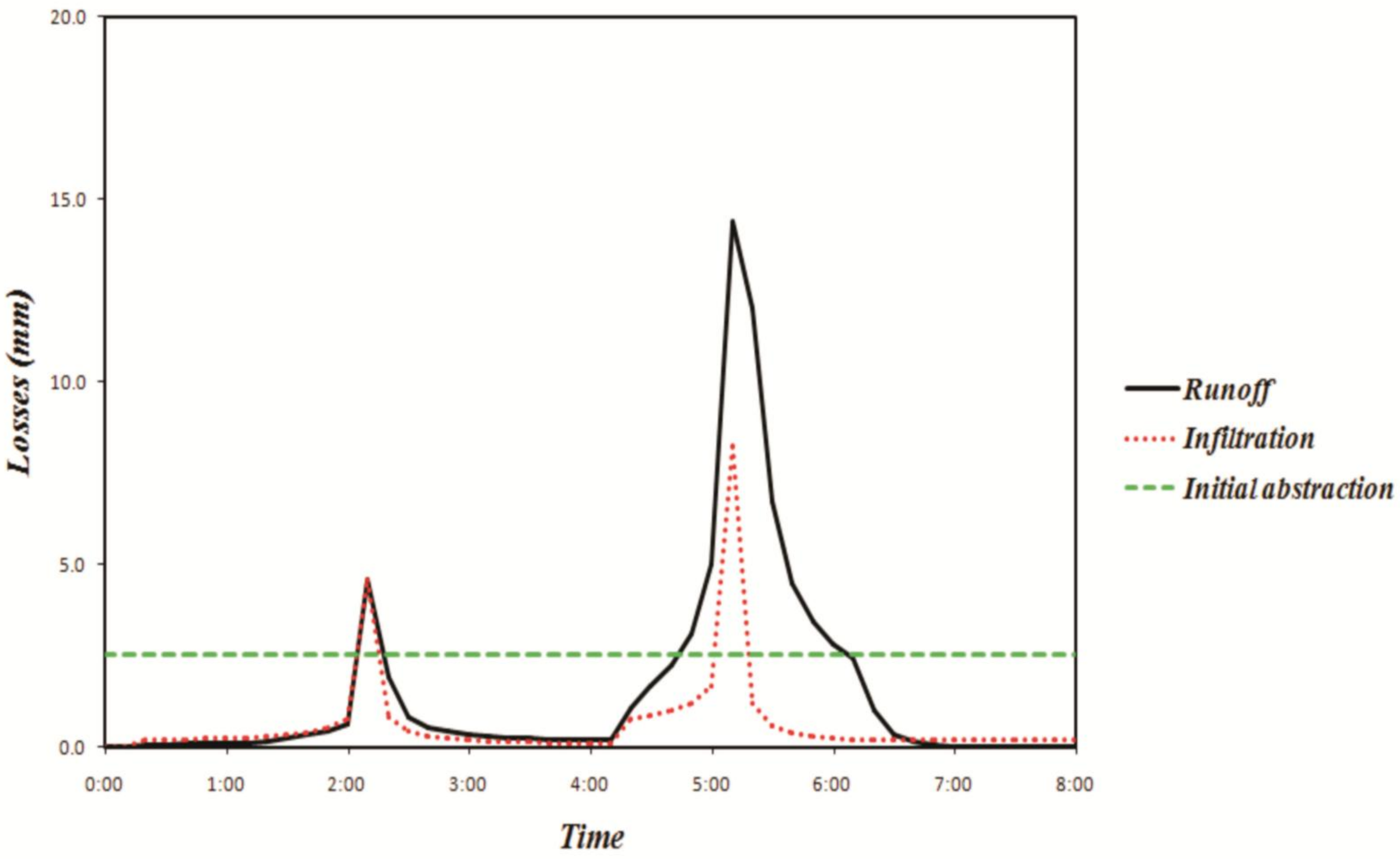
SWMM calibration



Synthetic rainfall

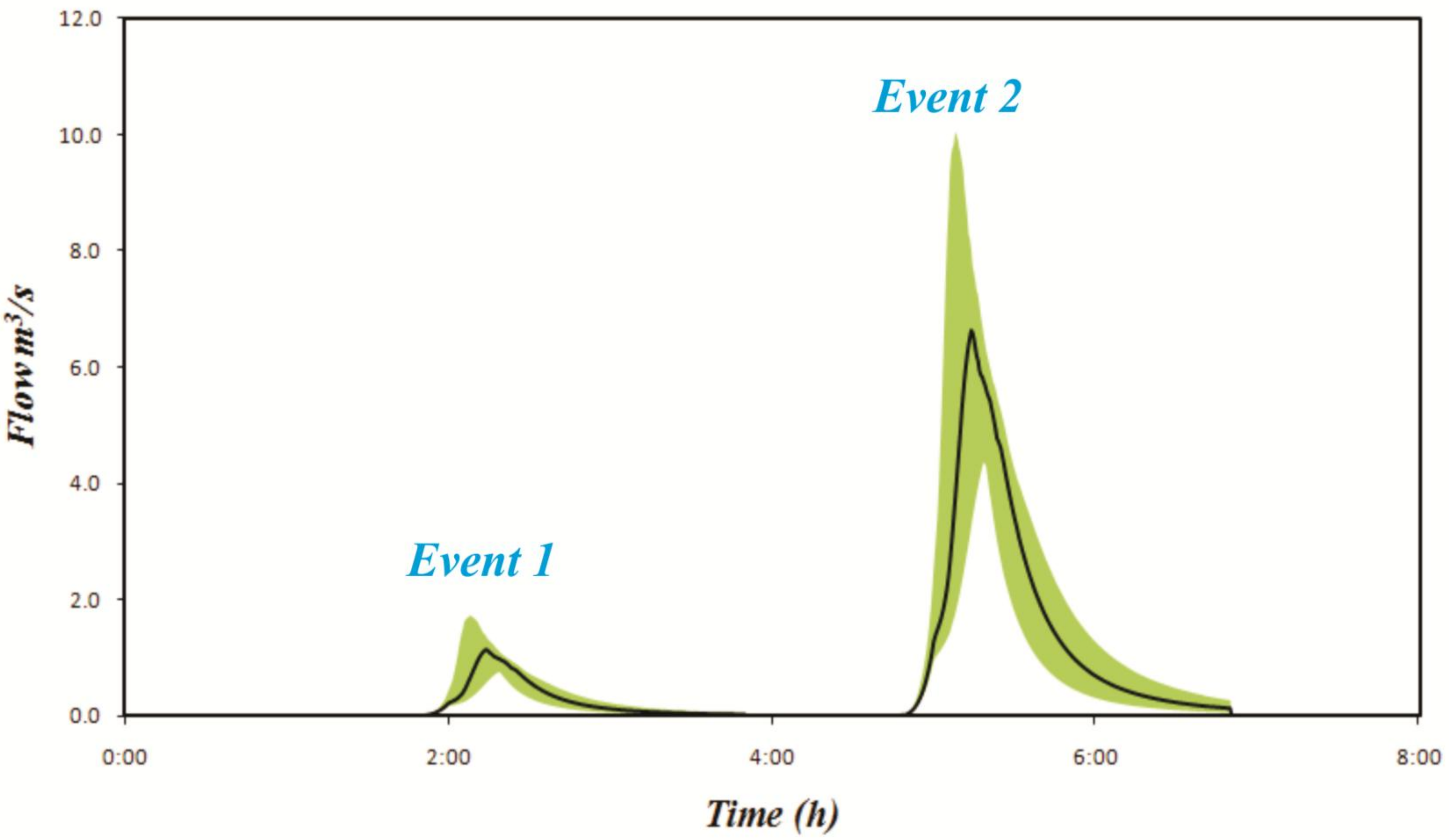


SWMM losses

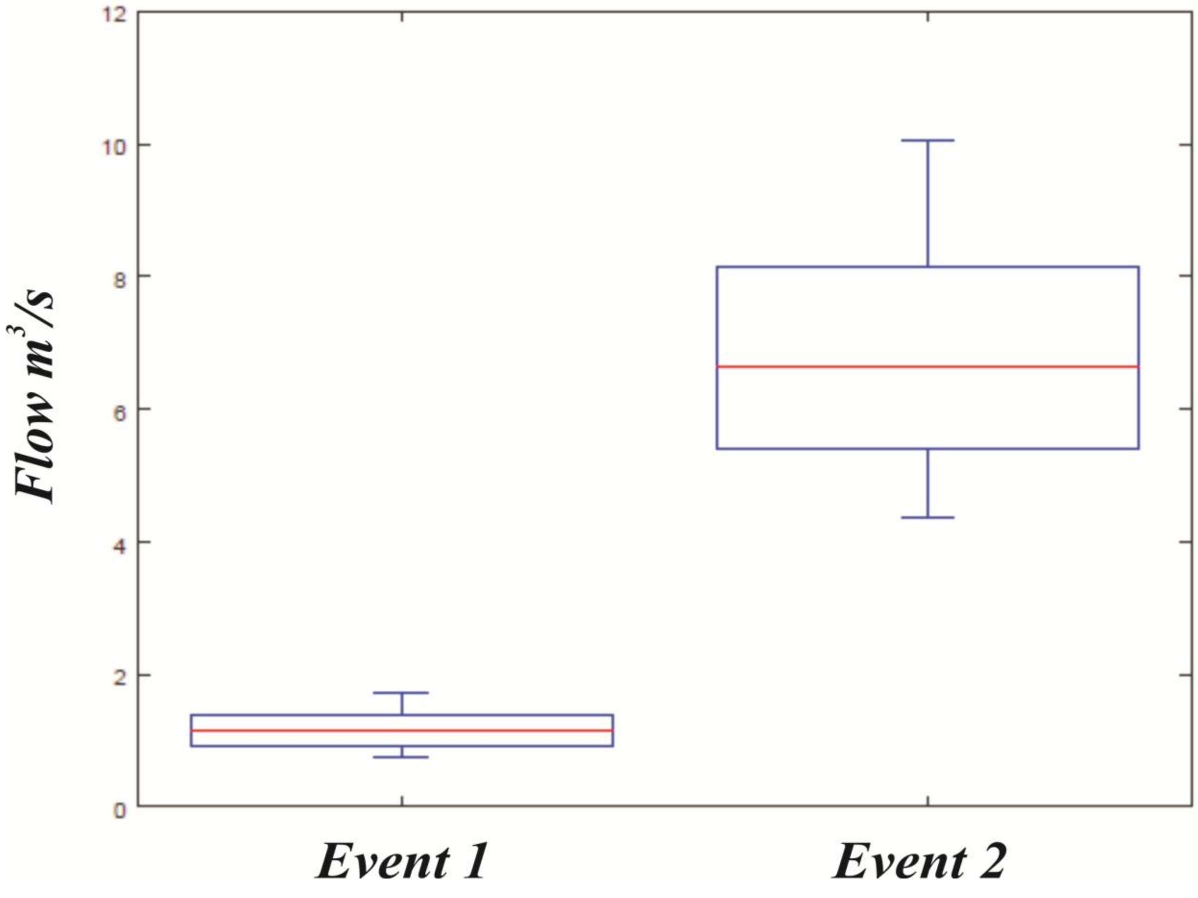


20.0
15.0
10.0
5.0
0.0
Losses (mm)
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
Time
Runoff
Infiltration
Initial abstraction

Superposition



Flood peaks



Conclusion

- Uncertainty band is of importance
  - wide range of parameters
  - lack of measurements
- More intense phenomena have as a consequence bigger uncertainties
- Useful and fast tool for Decision Making in ungauged basins
- High Performance Computing
  - derivation of ensembles in computationally expensive models
- Future work
  - emulation of UH derivation using data-driven techniques

water

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Special Issue

Quantifying Uncertainty in Integrated Catchment Studies

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Deadline for manuscript submissions:
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Message from the Guest Editors

Integrated catchment modelling is defined as the simulation of the linkage between the several sub-models, simulating processes of the water cycle (rural and urban) starting from the meteorological input, until the final recipient. These integrated catchment studies can be used to plan projects, to optimise systems, as well as to evaluate the need of certain measures. However, the stepwise process of abstraction from reality to model representation with its simplifications and idealisations of the real systems comes with the unavoidable occurrence of uncertainties. The definition, recognition and consideration of these uncertainties is, therefore, of the utmost importance for applying such models and for the interpretation of model results, in real world problems.

In this Special Issue we would like to invite research on integrated catchment studies for both quantity and quality modelling, specially focusing on the quantification of the uncertainty. Manuscripts which are coping with the following topics are specifically invited:

- quantification and the propagation of uncertainty at significant temporal and spatial scales in catchments
- approaches for minimising uncertainties in integrated models
- techniques for model reduction of computationally expensive models
- real world case studies on integrated catchment modelling
- tools, which can be deployed by end users considering all aspects of modelling uncertainty and hence they are able to be used in the context of the decision-making process

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