Uncertainty propagation in urban hydrology water quality modelling

J.A. Torres-Matallana, U. Leopold, G.B.M. Heuvelink

WAGENINGEN UNIVERSITY
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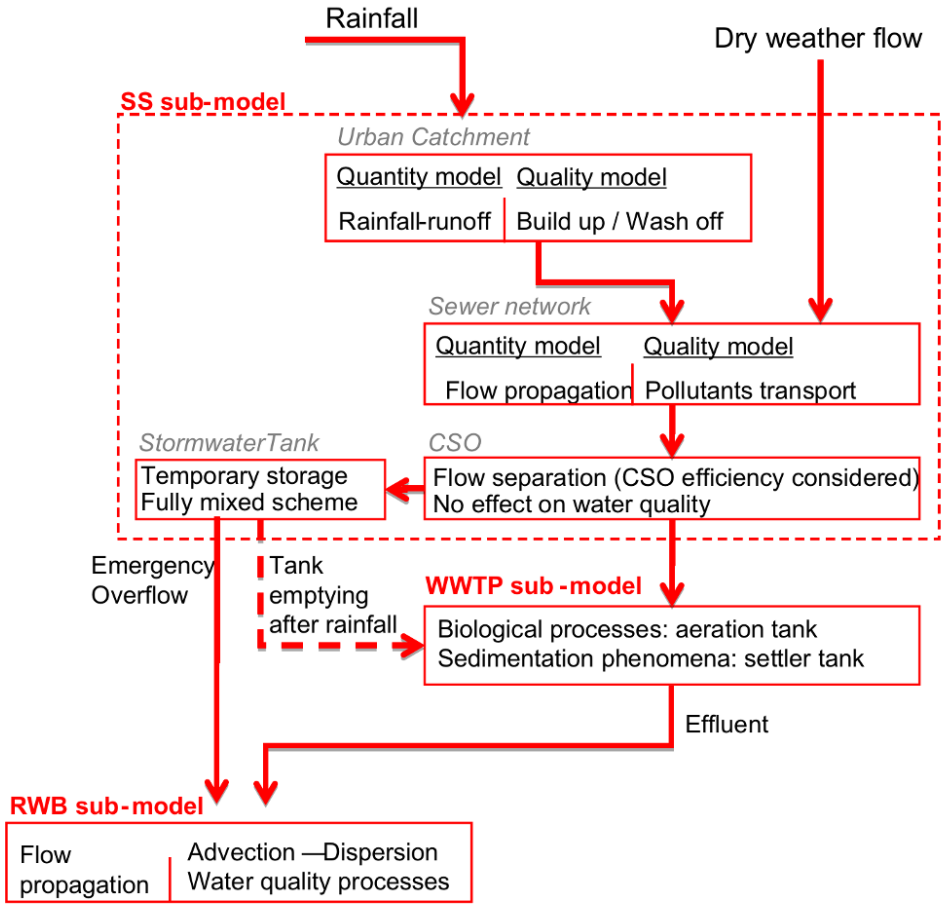
LIST

Challenges in UDM

- Sub-models at different spatial and temporal scales
- Requires up- and downscaling to connect sub-models correctly
- Uncertainties associated to model inputs, parameters, structure
- Uncertainties propagate across scales to model outputs

Integrated urban drainage models

Different sub-models, processes and interconnections



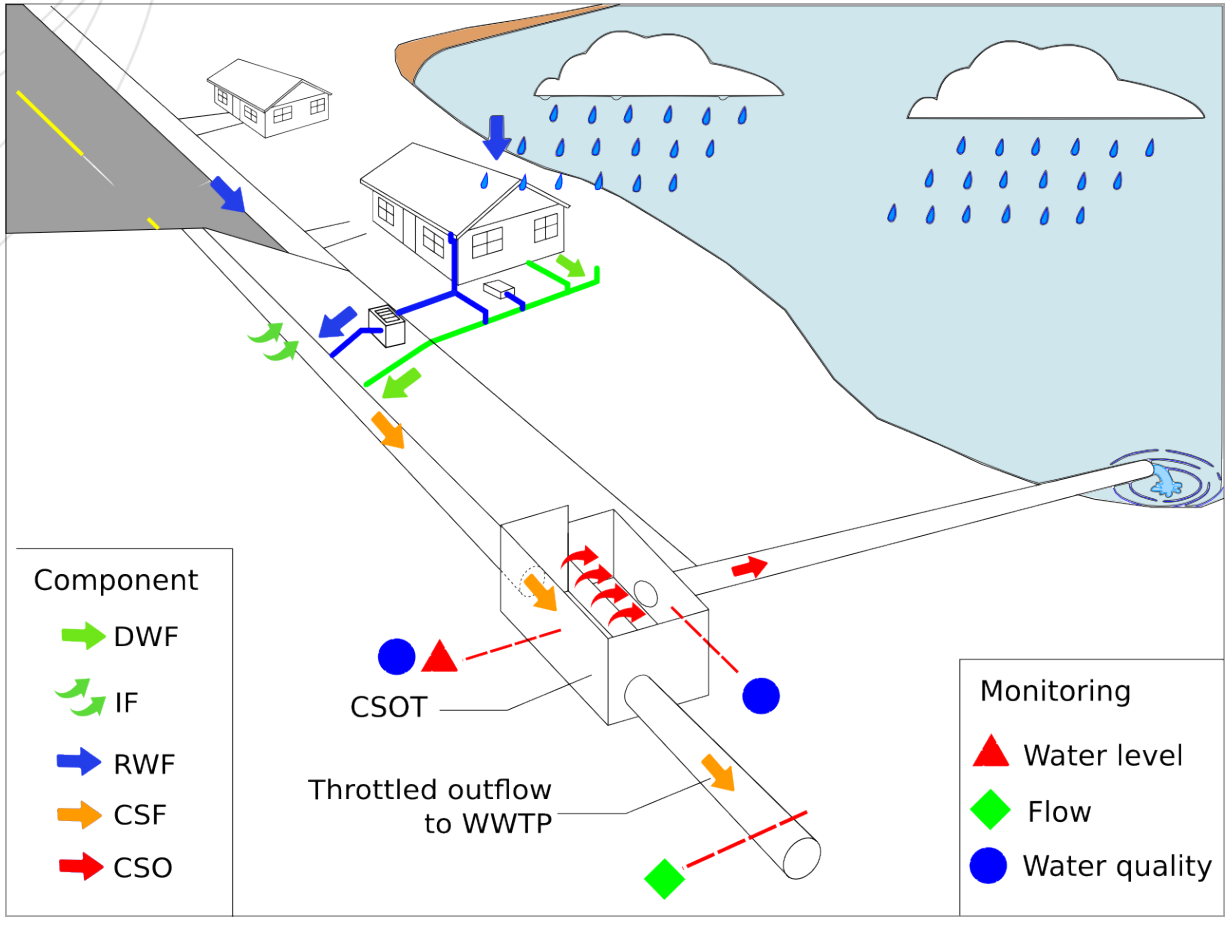
[Freni and Mannina, 2010].

Objectives of PhD project

- Overall objective:
  - Optimal complexity of urban drainage system models accounting for **spatial uncertainty** propagation, a step forward of the Water Framework Directive of the European Union.
  - Uncertainty propagation analysis through the urban drainage system model EmiStatR

- Specific research questions:
  - How can we identify and characterise the main sources of uncertainty within an Urban Drainage Model (EmiStatR)?
  - How do we propagate input uncertainties through Urban Drainage Models?
  - What are the contributions of input uncertainties to model output uncertainties?

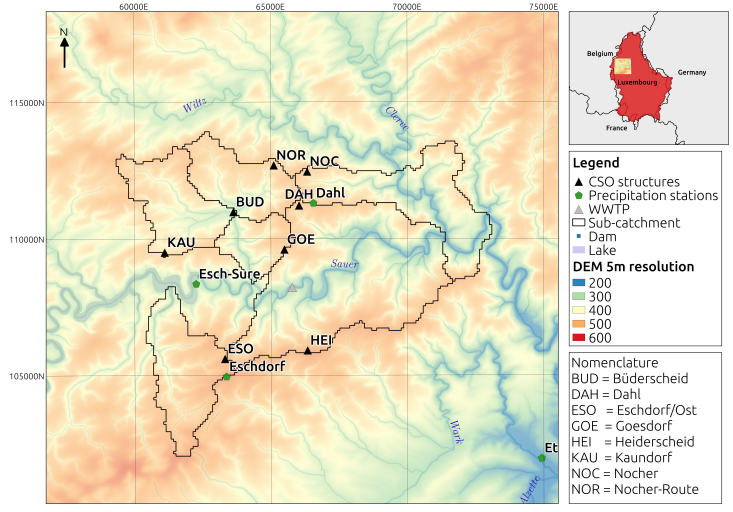
The EmiStatR model



1) Dry Weather Flow (DWF) including Infiltration Flow (IF); 2) Pollution of DWF; 3) Rain Weather Flow (RWF); 4) Pollution of RWF; 5) Combined Sewage Flow (CSF) and pollution; and 6) Combined Sewer Overflow (CSO) and pollution.

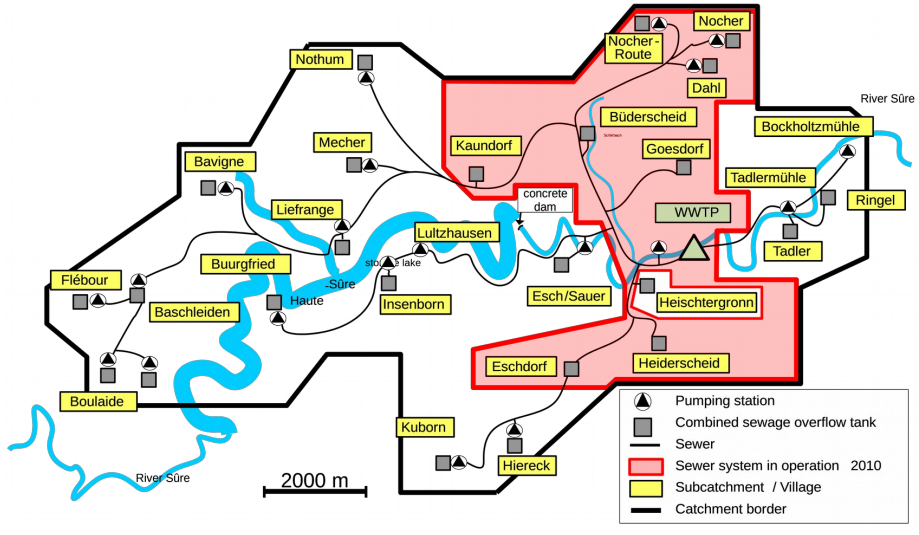
Data collection and study area

Catchment	Abbreviation
Boulaide Bauschelbusch	BAU
Boulaide Boellerbuch	BOE
Eschdorf	ESD
Goesdorf	GOE
Kaundorf	KAU
Nocher-Route	NOR



Data available 2010 – 2011

Location	Type of measurement
GOE	Rainfall Water level CSO and tank, outflow rate WWQ Campaign
KAU	Rainfall Water level, flow velocity, temperature WWQ Campaign
NOR	Rainfall Water level, flow velocity WWQ Campaign



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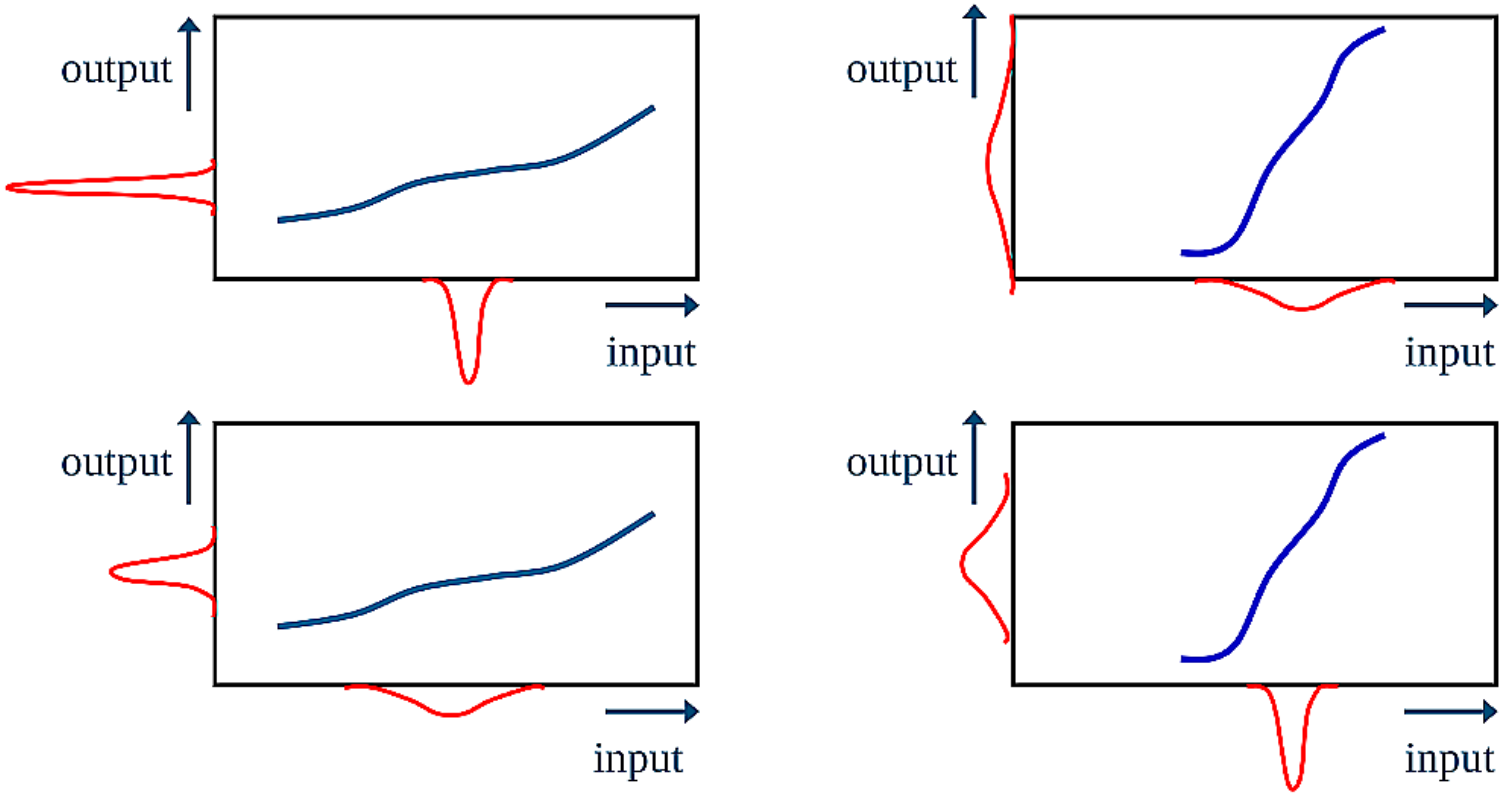
Identification of sensitivity model inputs

Model sensitivity and magnitude of input uncertainty



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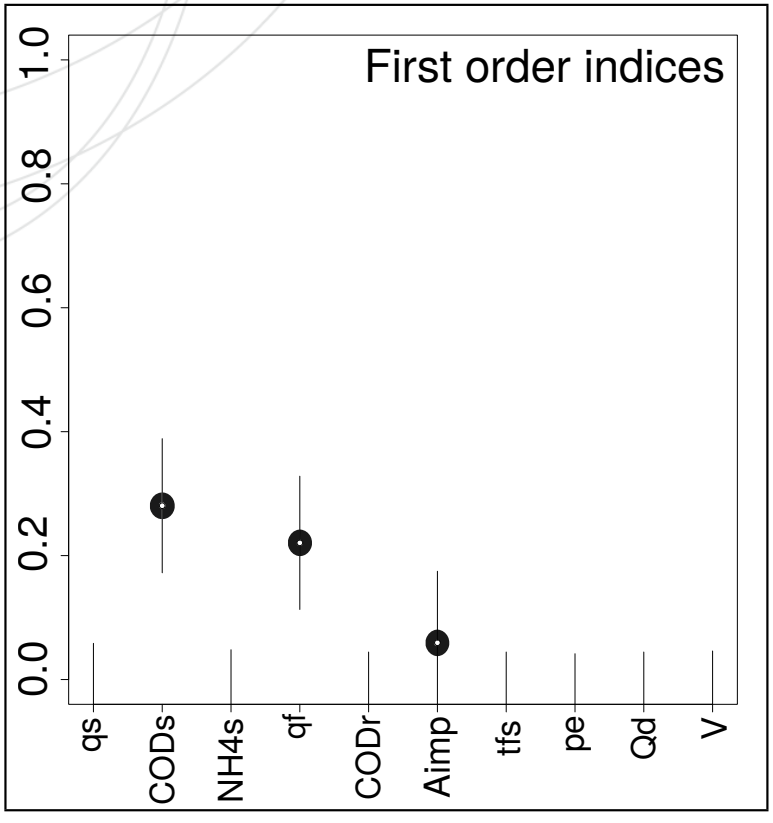
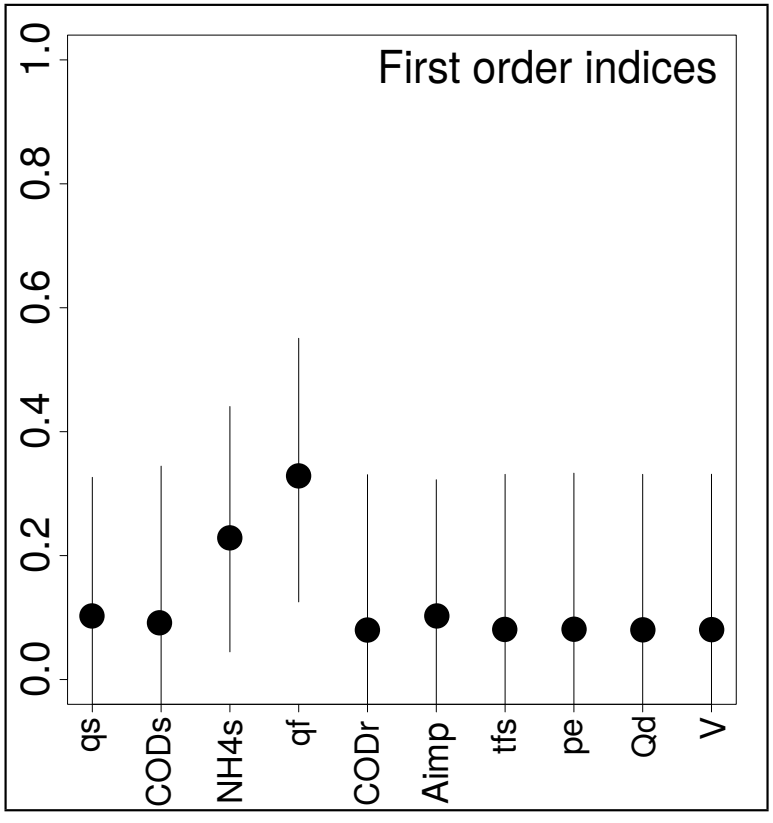
Screening of sensitive model inputs

[Monod, Naud, and Makowski, 2006],
[Janon, Klein, Lagnoux-Renaudie, Nodet, and Prieur, 2014]



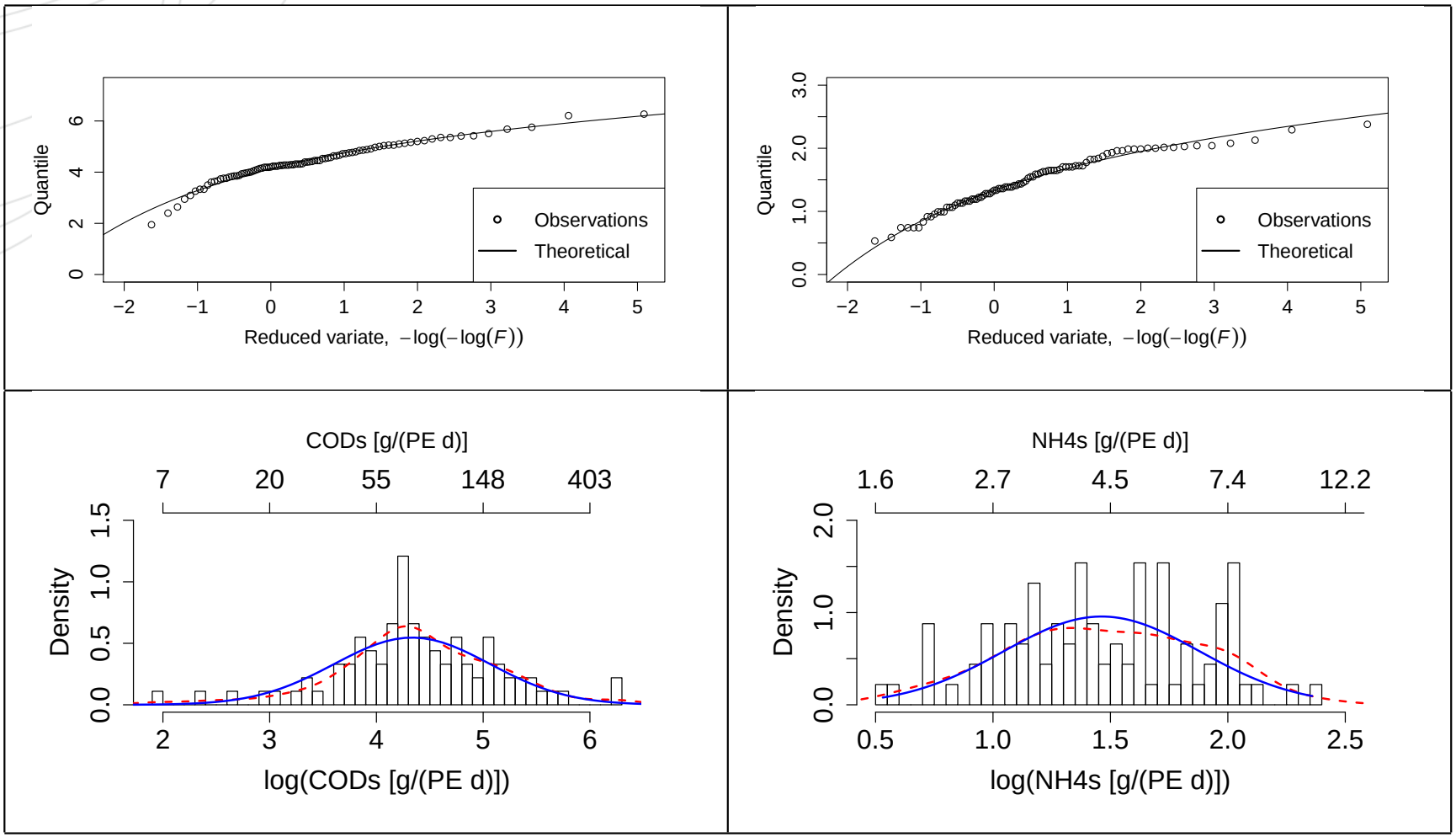


First order Sobol's indices according with RMSE (left), and NSE (right).
S2 = CODs; S4 = qf; S6 = Aimp; S3 = NH4s. (3,300 Monte Carlo simulations).

Selection of model inputs for U. propagation

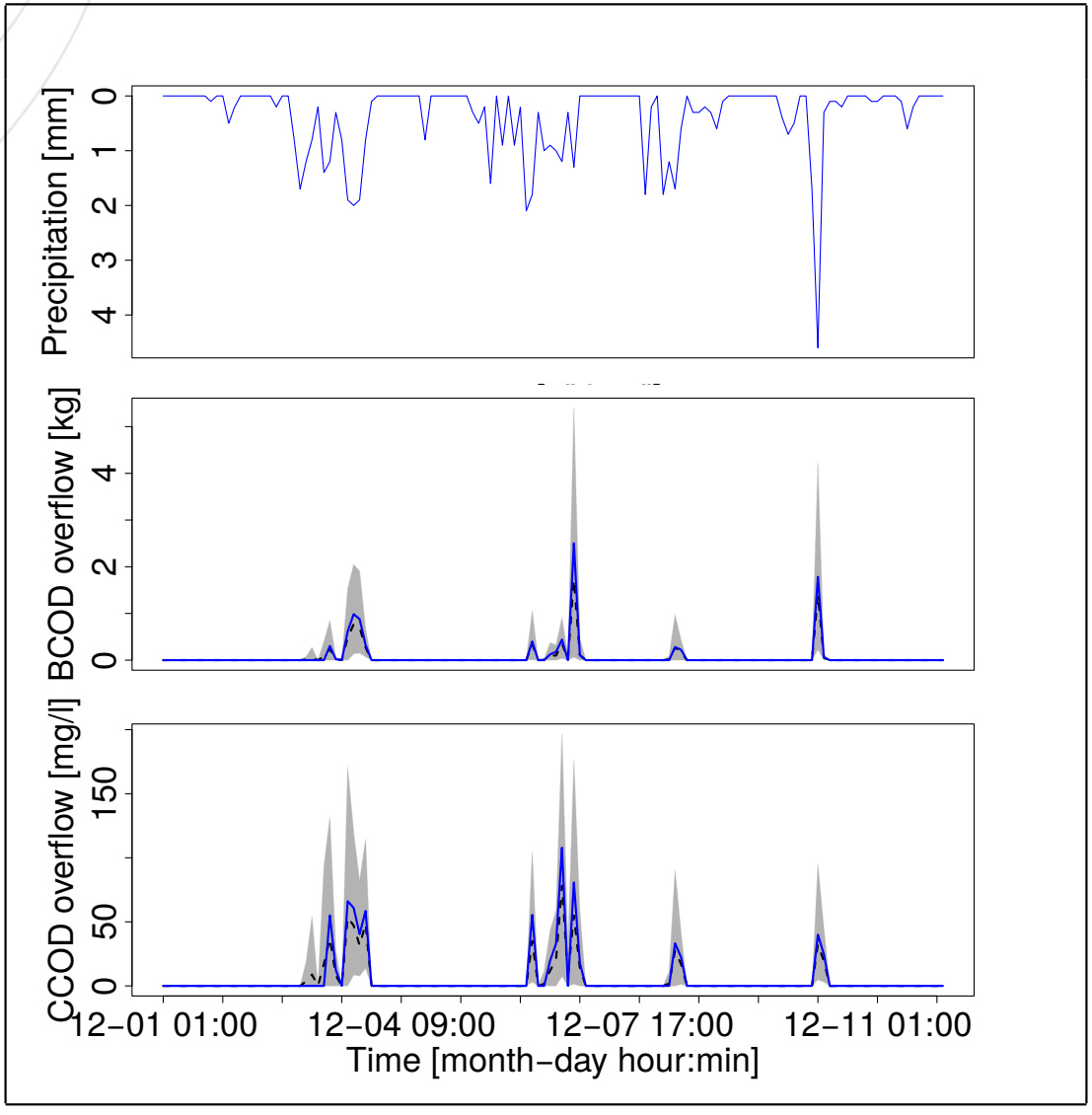
Input variable	Input uncertainty	Model sensitivity	Uncertainty analysis
Wastewater			
1. qs	$+$	$+$	no
2. $CODs$	$++$	$++$	**yes**
3. $NH4s$	$++$	$++$	**yes**
Infiltration water			
4. qf	$++$	$-$	no
5. $CODf$	$--$	$--$	no
6. $NH4f$	$--$	$--$	no
Rainwater			
7. $CODr$	$++$	$++$	**yes**
8. $NH4r$	$--$	$--$	no
9. P	$++$	$++$	**yes**
Storm water runoff			
10. tf	$--$	$--$	no
Sub-catchment			
11. LU	$+$	$--$	no
12. $Ages$	$+$	$--$	no
13. $Aimp$	$++$	$++$	**yes**
14. pe	$-$	$++$	no
15. tfs	$-$	$--$	no
CSO structure			
16. Qd	$-$	$++$	no
17. V	$-$	$++$	no

$CODs$ and $NH4s$ observations

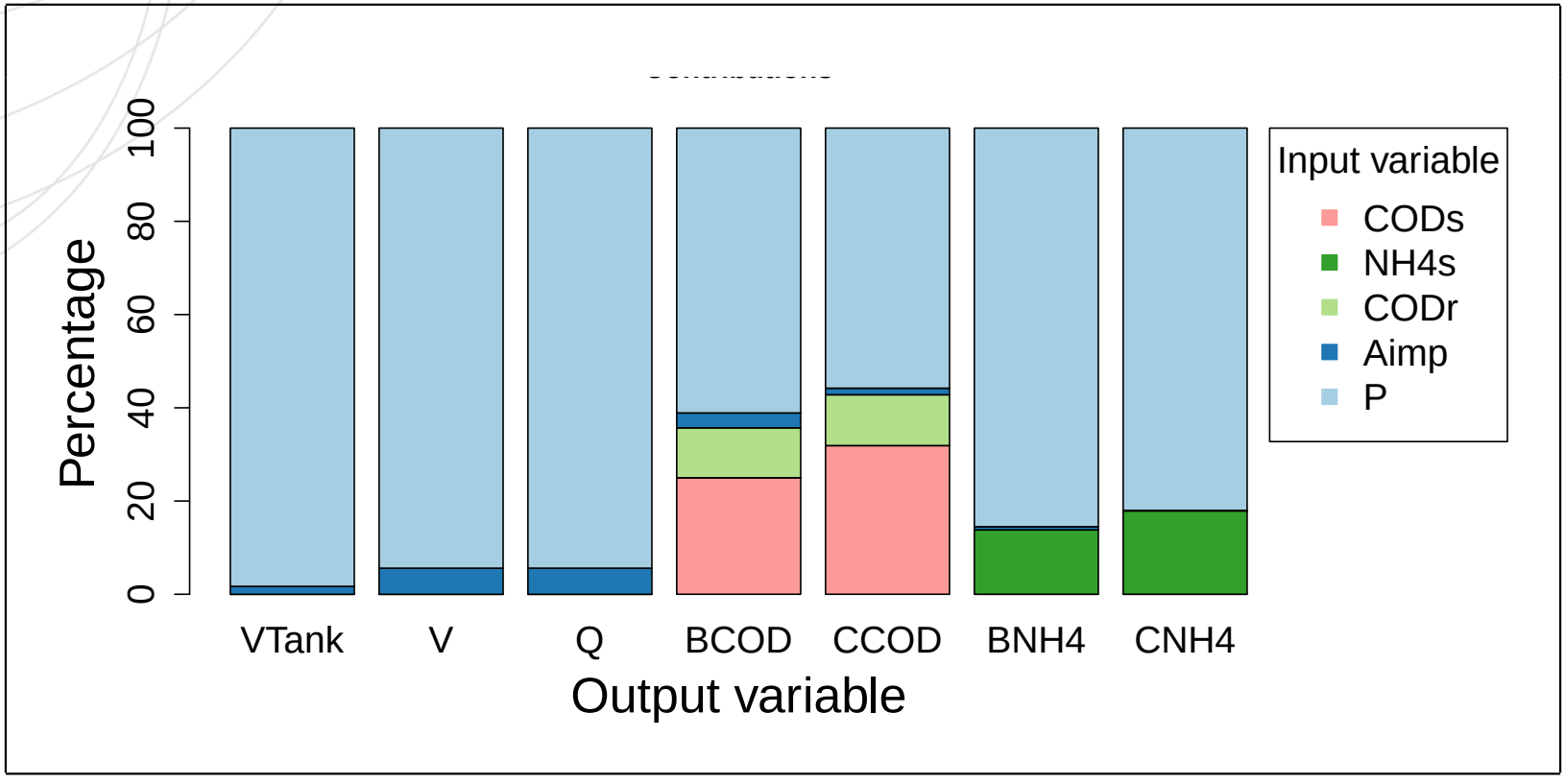


Quantile plot (top). Histogram, empirical density and theoretical normal density (bottom).

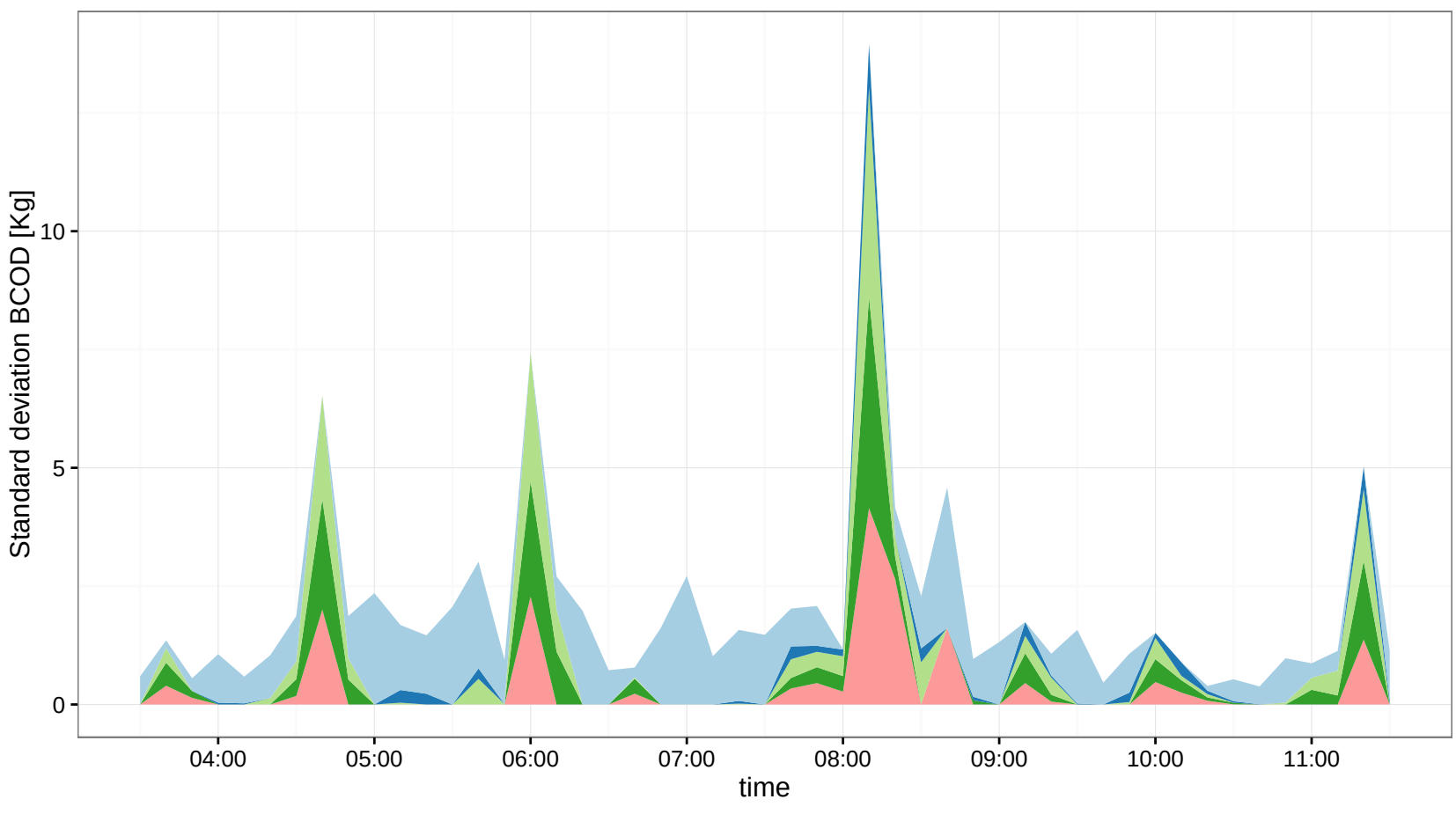
Overflow event in winter 2009-2010



Contributions of input to overall output U.



Input uncertainty contributions over time



Conclusions

- SA helps to identify the main sources of uncertainty in urban drainage models (UDMs)
- Combined approach MC and SA is suitable for temporal (and spatial) uncertainty propagation through UDMs and the apportioning of input uncertainties
- The approach helps practitioners to better account for uncertainties for:
  - Design and dimensioning of Urban Drainage Systems
  - Pollution control of receiving water bodies

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Thank you!

arturo.torres@list.lu

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Hervé Monod, Cédric Naud, and David Makowski. *Working with Dynamic Crop Models*, chapter Uncertainty and sensitivity analysis for crop models, pages 55–100. Elservier, 2006. ISBN 0444521356.