Sylvain Coutu

Parsimonious hydrological modelling in urban areas: Towards integrated modelling

(S. Coutu, D. Del Giudice, L. Rossi, D. A. Barry)

Urban Drainage Modelling Conference, Belgrade (2012)

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Why another hydrological model?

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Environmental Modelling & Software

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Position Paper[1]

Ten iterative steps in development and evaluation of environmental models

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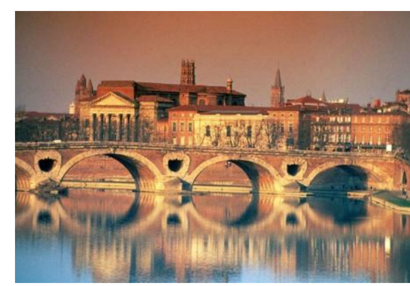
Step 1: Definition of the purposes for modelling

Micropollution: a Worldwide Growing Concern

- Micropollutants identified in many countries in the world, across all continents.
- Feminization of fish due explained by the occurrence of high concentration of hormones
  (Jobling et al., 1996, *Environmental Toxicology and Chemistry*)
- Decline of vulture population in Pakistan explain by ingestion of Diclofenac
  (Oaks et al., 2004, *Nature*)



Selection of model features

Flexibility

Sewage Network & Urban Rivers

Automatic Calibration

Support for further integrated modelling

Fast computation time

Limits of existing models

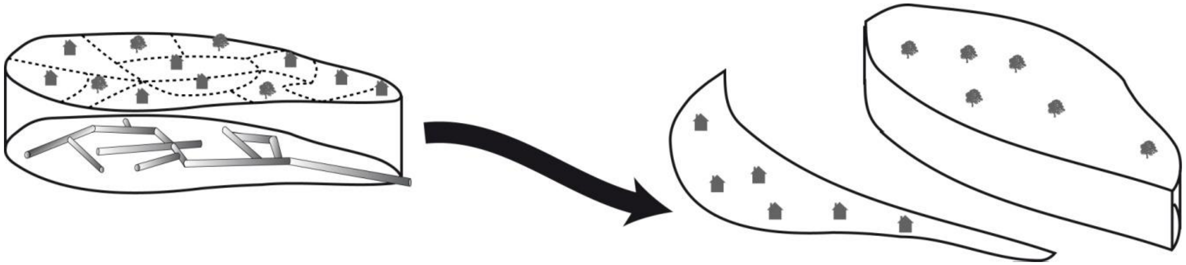
Popular existing model (e.g., MOUSE, SWMM, etc) are distributed

More variables --- Require quantities of data --- Computation time

Unfit to integrated modelling

Parsimonious modelling --- Tested rural environment

Ignore the complexity of drainage system



Map of the presentation

Conceptual description of the model

Calibration
&
Validation

Examples of
Application for integrated
modelling

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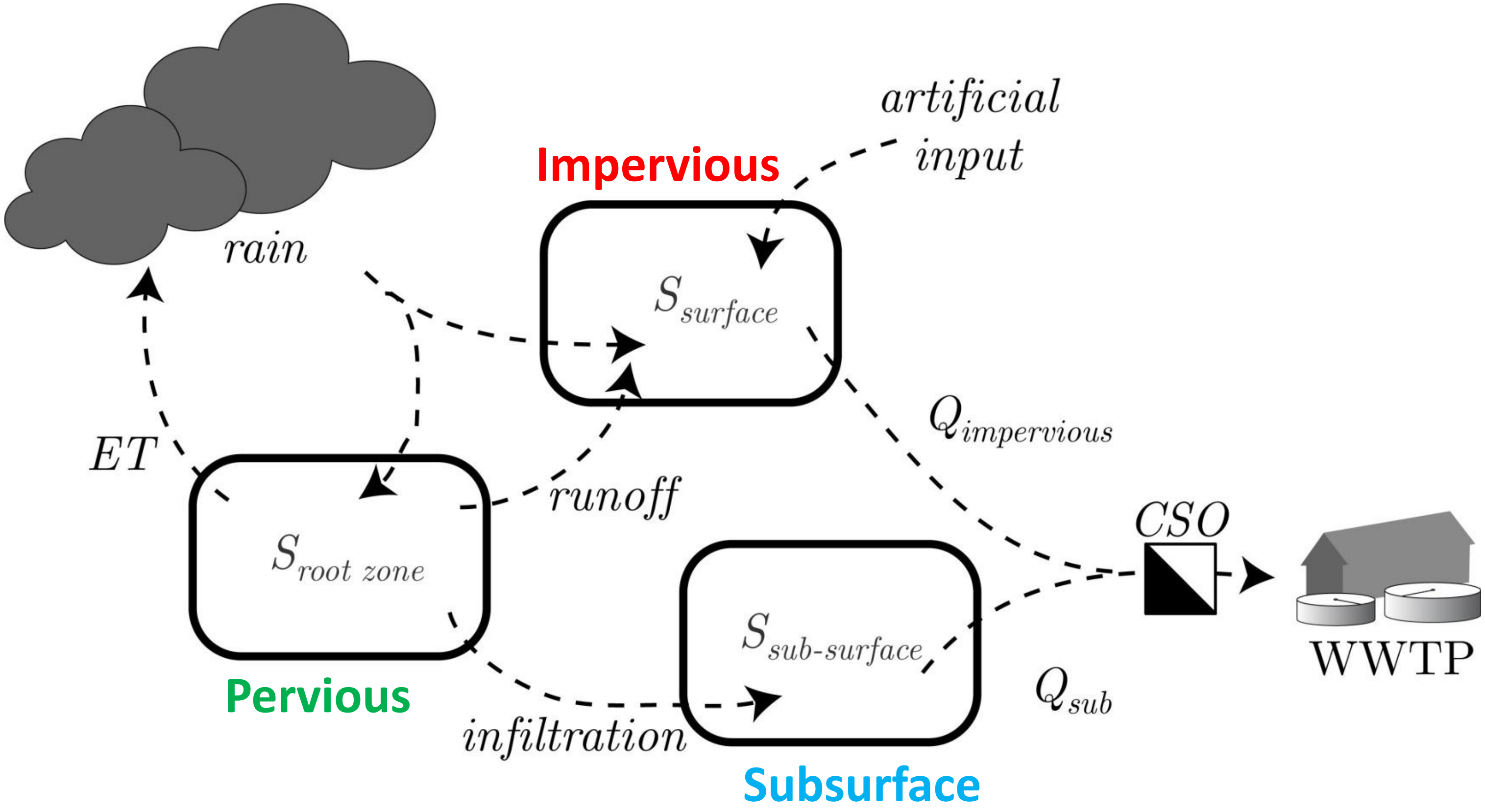
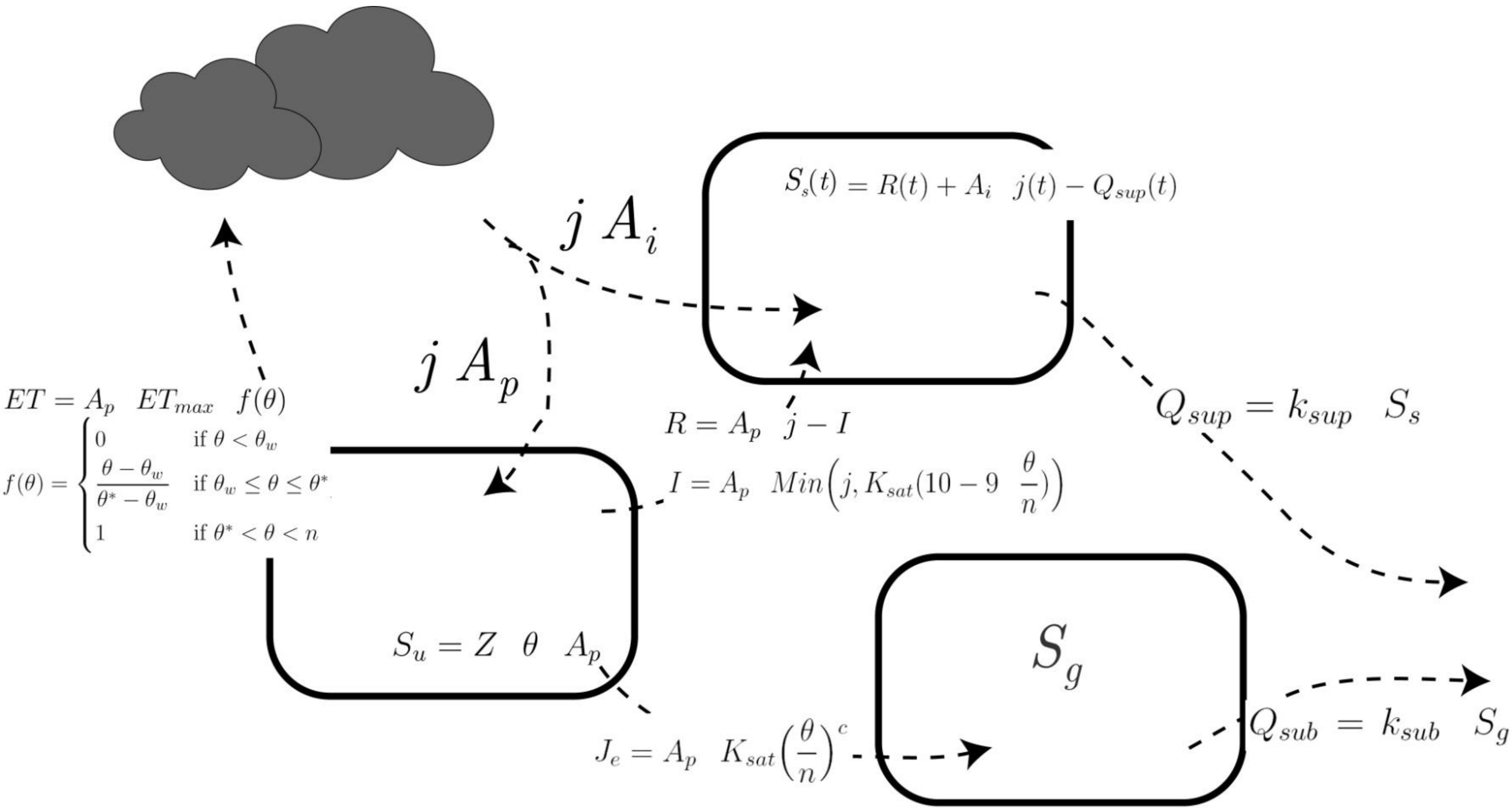
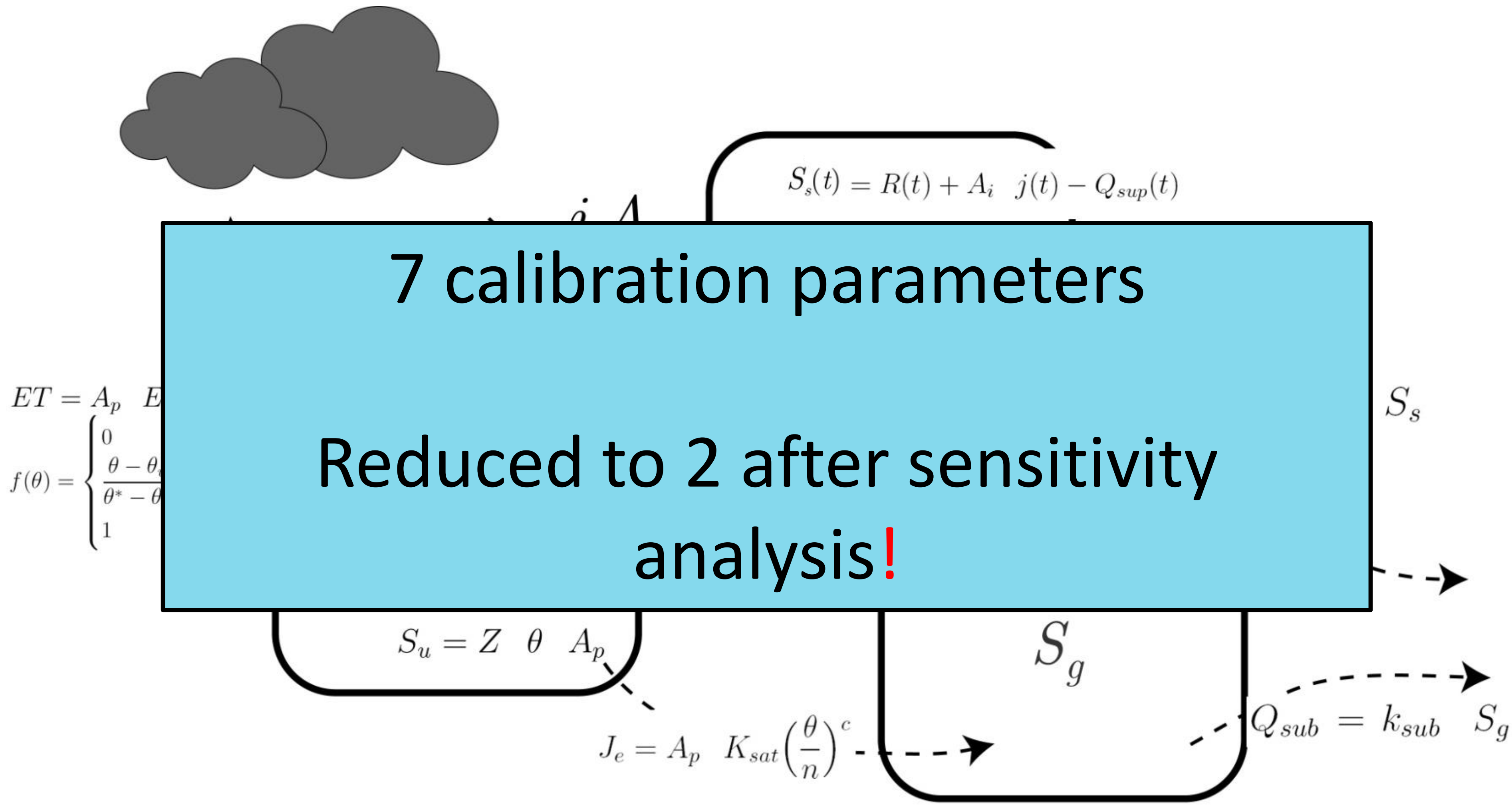
Precipitation/discharge model (Coutu et al., 2012)

Lumped parsimonious approach is efficient for modeling both **urban AND rural** watershed



Precipitation/discharge model (Coutu et al., 2012)

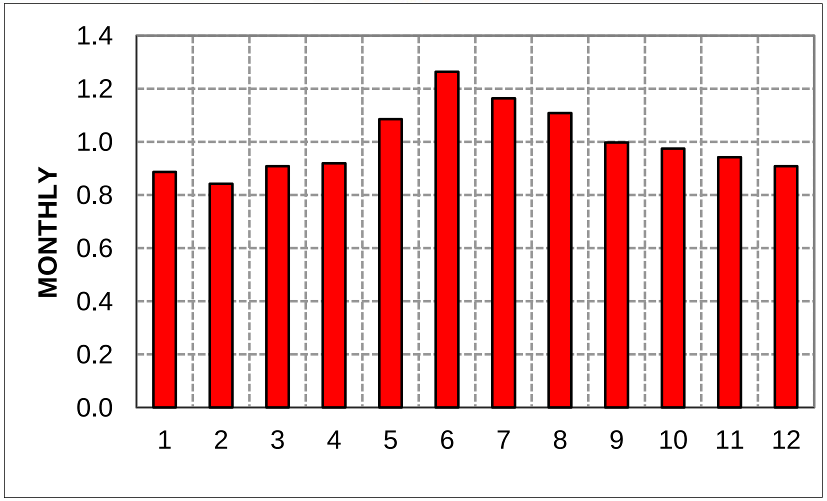


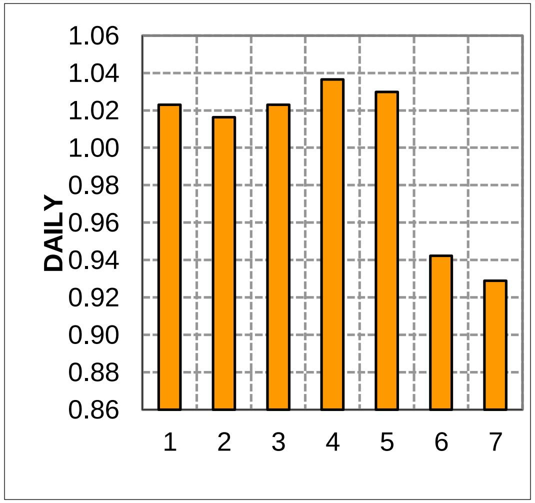


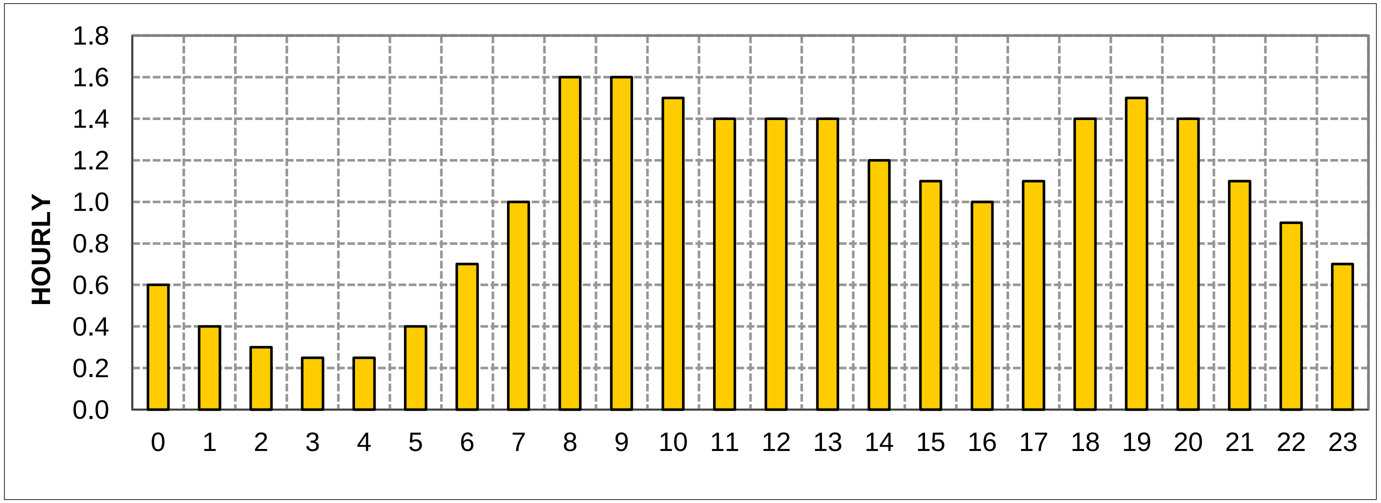
7 calibration parameters

Reduced to 2 after sensitivity analysis!

Statistical achievement of baseflow at WWTP

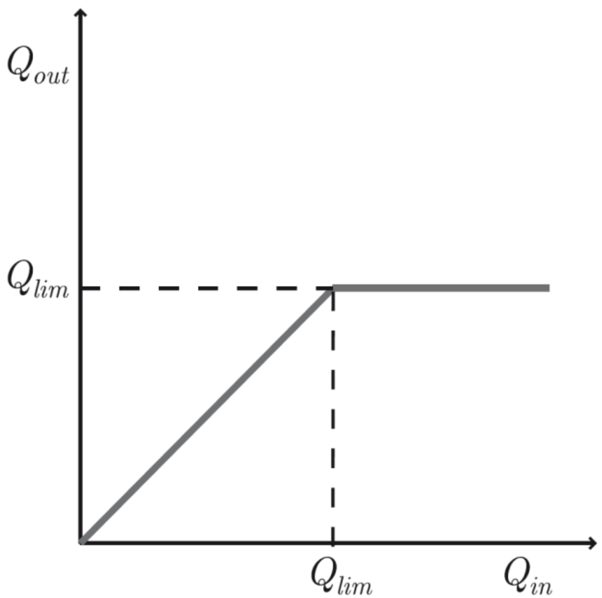






Big thanks to Jordan (2010), e-dric and Ville de Lausanne

Lumping all CSOs to a single representative one



- A single, representative flow delimiter models the effect of all CSOs of the system in a lumped fashion manner
- This representative CSO is modeled using a diversion law that follows a linear threshold-limited function
- It is possible for two reasons:
  (i) it is the first CSO to discharge water when rain occurs
  (ii) it is the last CSO before our flow measurement point

Map of the presentation

Ignorance of the sewer network
Same framework for river and sewage network
CSOs lumped into a single representative one

Calibration
&
Validation

Examples of
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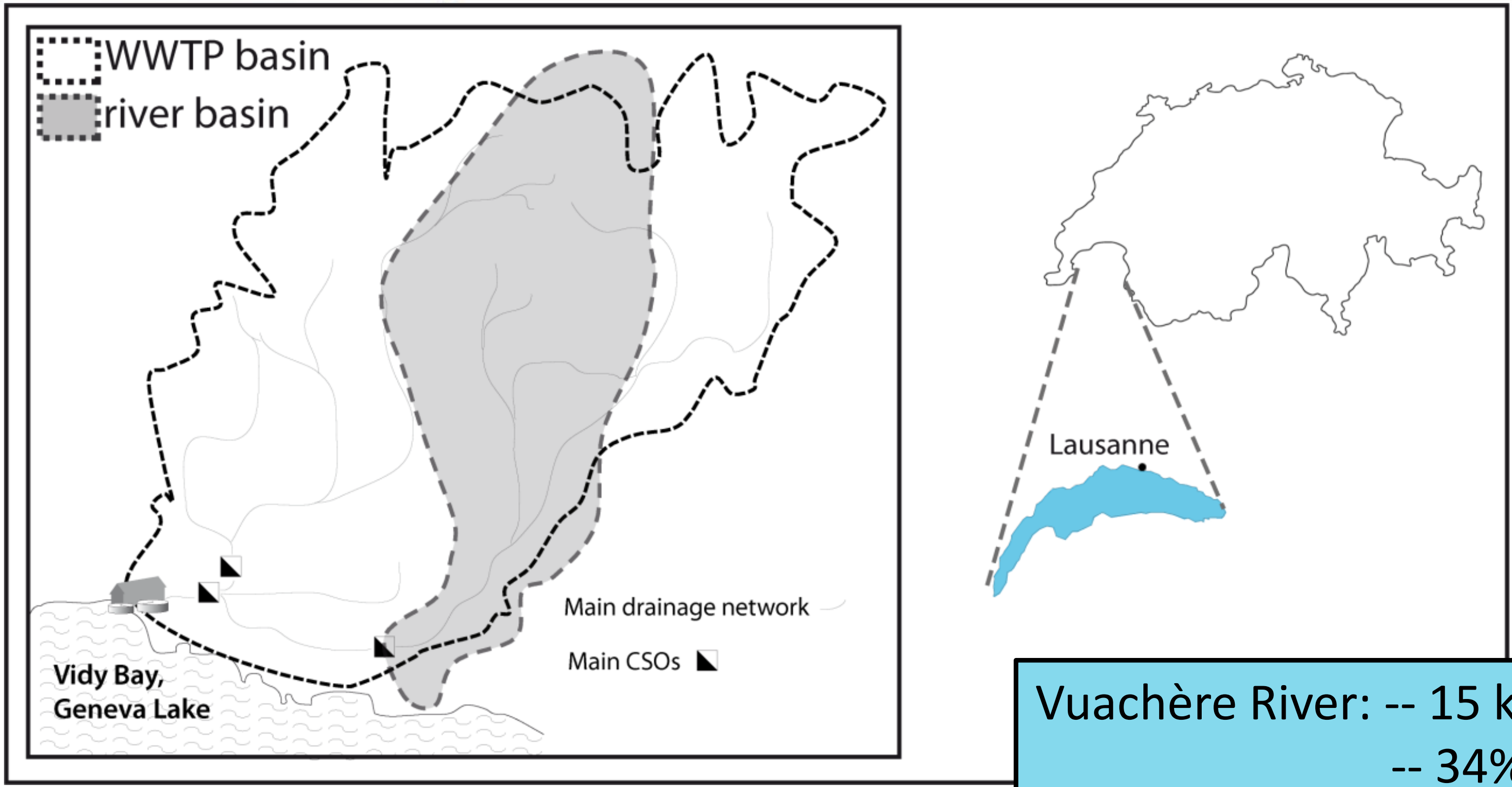
Presentation of a “two in one” case study

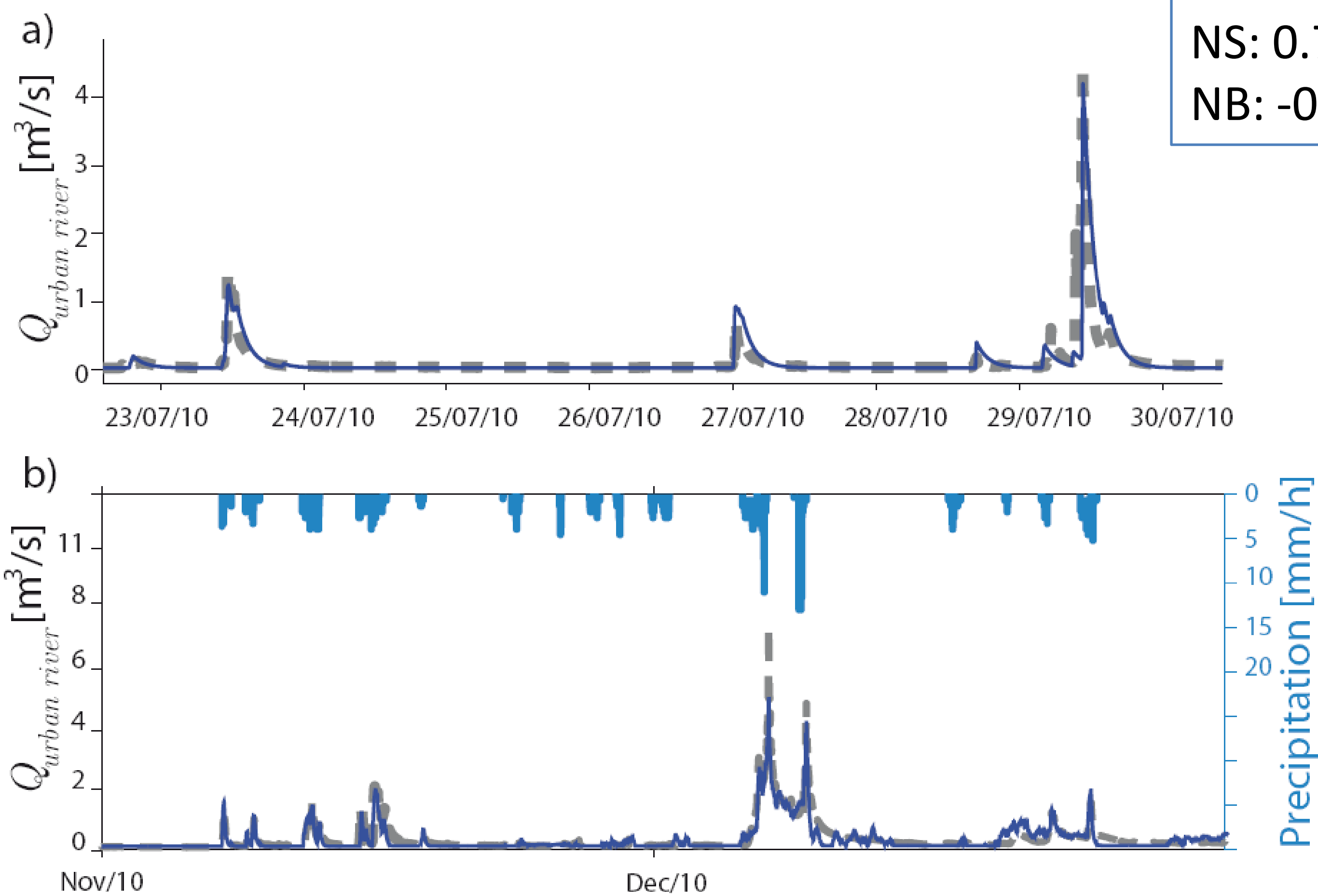


Vuachère River: -- 15 km^2
-- 34% impervious.

Vidy WWTP: -- 37km^2
-- 25% impervious
--200.000 inhabitants

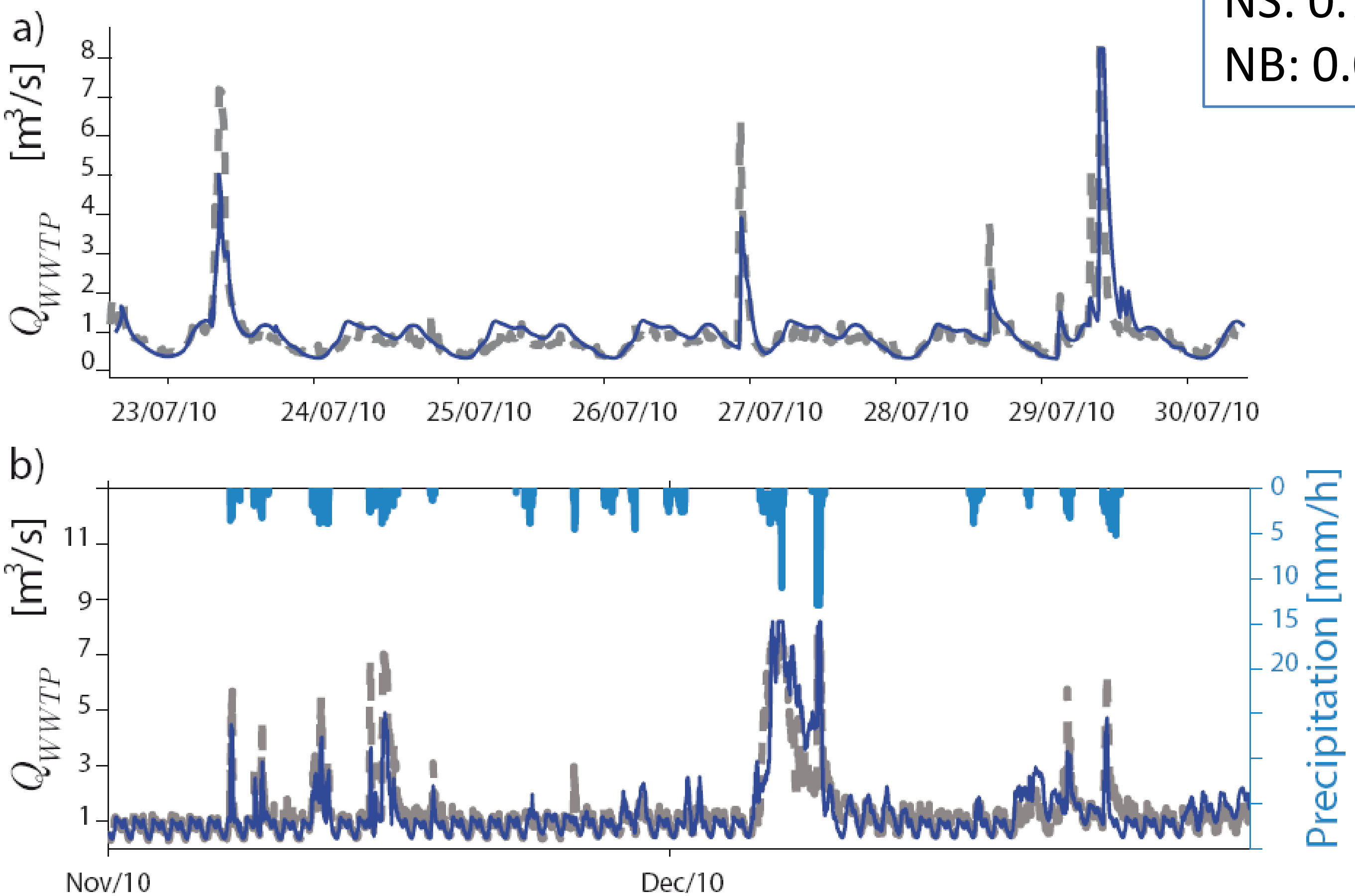
Calibration & Validation results for the river

Performance criteria:
NS: 0.73 (optimal = 1)
NB: -0.0057 (optimal = 0)

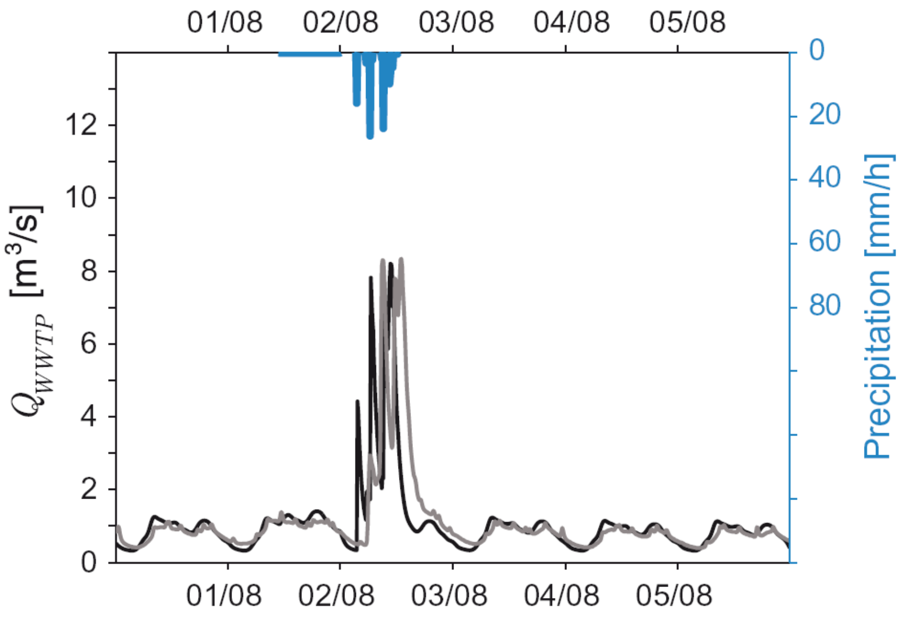


Calibration & Validation results for the WWTP

Performance criteria:
NS: 0.72 (optimal = 1)
NB: 0.001 (optimal = 0)



Comparison with the a distributed model



Black: our model
Grey: distributed model

- Comparable performances
- 12 CSOs lumped into one
- Over 40 sub-basins lumped into one
- No information of pipe network
- Easier to calibrate
- Smaller computation time (20s vs 0s)

Ignorance of the sewer network
Same framework for river and sewage network
CSOs lumped into a single representative one

Good performance on:

1) **River**
2) **Sewer flow**

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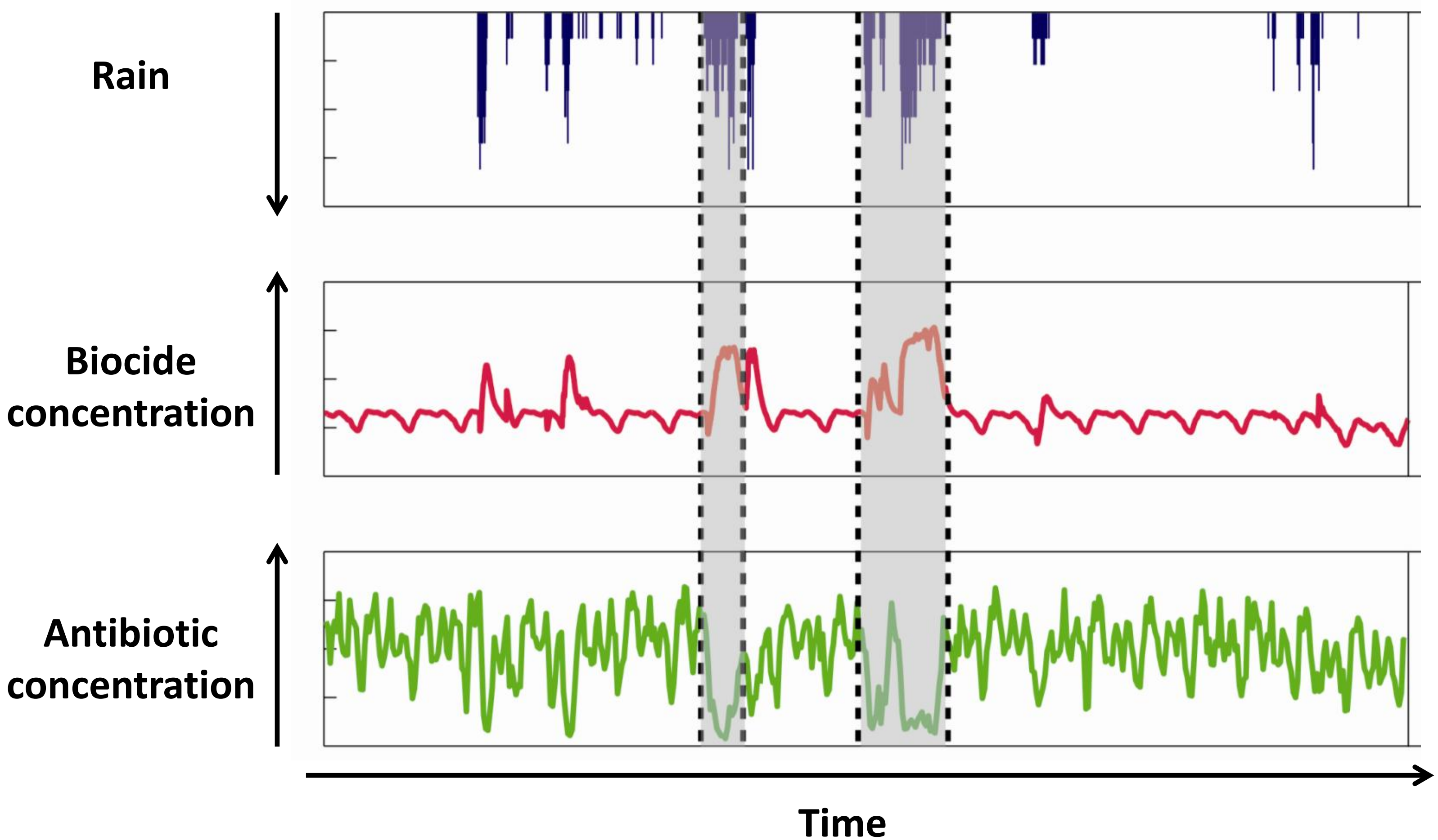
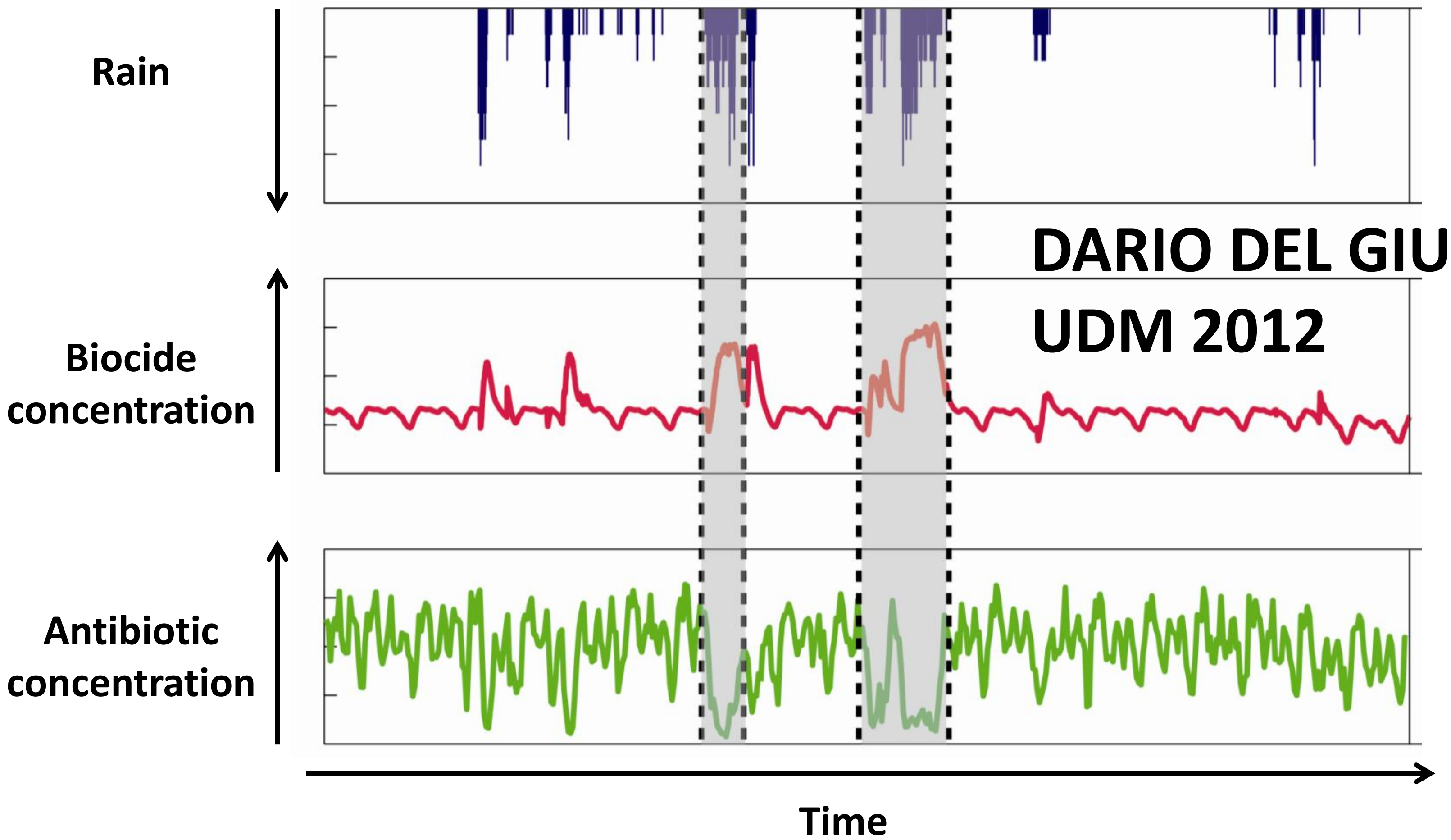
Example of integrated modelling



Example of integrated modelling



DARIO DEL GIUDICE, UDM 2012

Map of the presentation

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Support for integrated modelling of multiple sources of pollution with complex dynamics

For more details

Contents lists available at SciVerse ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Parsimonious hydrological modeling of urban sewer and river catchments

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CONCLUSION

- The pipe network is replaced by underground impervious area
- All CSOs are lumped into a representative one
- Efficient for sewer system and urban rivers
- Potential for further integrated water quality modelling

QUESTIONS?

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Multiple scientific concerns

What is the control point?

- WTP entrance for optimizing treatment strategy
- WTP outlet and CSOs for environmental impact
- Urban rivers

What are the source dynamics?

- Medical prescription
- Illicit drug habits
- Pesticides in agriculture

What are the transport dynamics?

- Dynamics of the sewer system
- Dynamics of an urban river

Multiple scientific concerns

What is the control points?

Depends on the objective

What are the source dynamics?

Depends on the substance

What are the transport dynamics?

- Dynamics of the sewer system
- Dynamics of an urban river

Automatic calibration algorithm

Criterion function	Expression	Optimal value
Nash–Sutcliffe	$1-\frac{\sum_{i=1}^{n}[Z_{obs}(i)-Z_{sim}(i)]^2}{\sum_{i=1}^{n}[Z_{obs}(i)-\overline{Z}_{obs}]^2}$	1
Normalized Bias	$\frac{\sum_{i=1}^{n}[Z_{obs}(i)-Z_{sim}(i)]}{n\overline{Z}_{obs}}$	0

Parameter	Symbol	Lower bound	Upper bound
Saturated conductivity	K_{sat} $(m\ s^{-1})$	$1.4\ \times 10^{-6}$	$2.6\ \times 10^{-5}$
Wilting point	θ_w	0.14	0.26
Clapp exponent	c	1	20
ET parameter	a	-4.8	-0.84
ET parameter	b	0.7	1.19
Subsurface discharge rate	k_{sub} (s^{-1})	$2.8\ \times 10^{-8}$	$3.8\ \times 10^{-7}$
Surface discharge rate	k_{sup} (s^{-1})	$2.0\ \times 10^{-5}$	$3.8\ \times 10^{-4}$

$$Min\{(1-NS)+|NB|\}$$