A conceptual modelling tool
for water quality and sediment transport

Jiri Nossent, Befekadu Taddesse Woldegiorgis,
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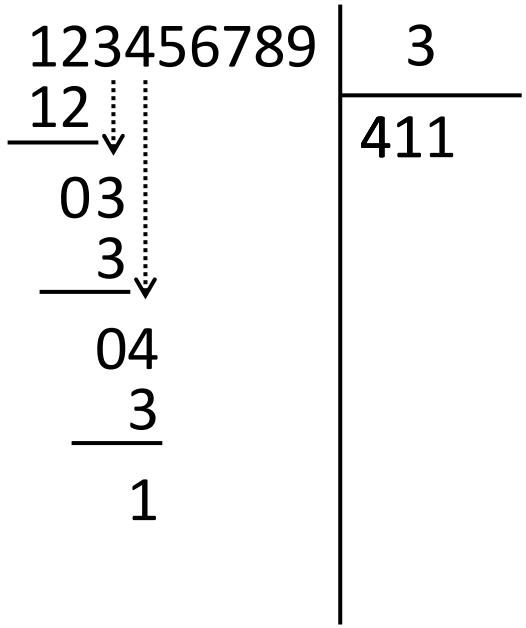
VRIJE UNIVERSITEIT BRUSSEL

Vlaanderen
is mobiliteit & openbare werken

Is 123456789 divisible by 3?



Is 123456789 divisible by 3?

1+2+3+4+5+6+7+8+9=?

45

Is 45 divisible by 3?

Yes!

123456789 is divisible by 3!

Water managers need adequate and reliable evaluations

of the complex water quality problems and the strategies to solve them

Detailed, complex WQ simulators

- Detailed WQ process representation
- Complex hydraulic simulations
- E.g. RWQM-VUB

Time consuming!

- Not suitable for long-term simulations
- Not suitable for SA, UA and auto-calibration

Water managers need adequate and reliable evaluations

of the complex water quality problems and the strategies to solve them

Simple and efficient conceptual models

Development of conceptual models for an integrated catchment management

KU LEUVEN

Q

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WQ

Water managers need adequate and reliable evaluations

of the complex water quality problems and the strategies to solve them

Conceptual model for WQ

Simple representation of the reality

Qual2E based equations

No hydrodynamics

Linked with conceptual model for Q

Reaches assumed to behave as CSTR

Computationally efficient

Suitable for long-term simulations

Suitable for multiple model runs

Water managers need adequate and reliable evaluations

of the complex water quality problems and the strategies to solve them

The CITOWA conceptual WQ model can be an efficient and adequate alternative for detailed WQ models

A quasi-analytical solution scheme

leads to stable and consistent numerical results

A probabilistic size-selective sediment transport simulator

provides an adequate representation without detailed hydrodynamic calculations

The **C**onceptual **I**ntegrated **To**ol for **W**Q **A**ssessment

can be applied for simulations in complex networks and for reverse flows

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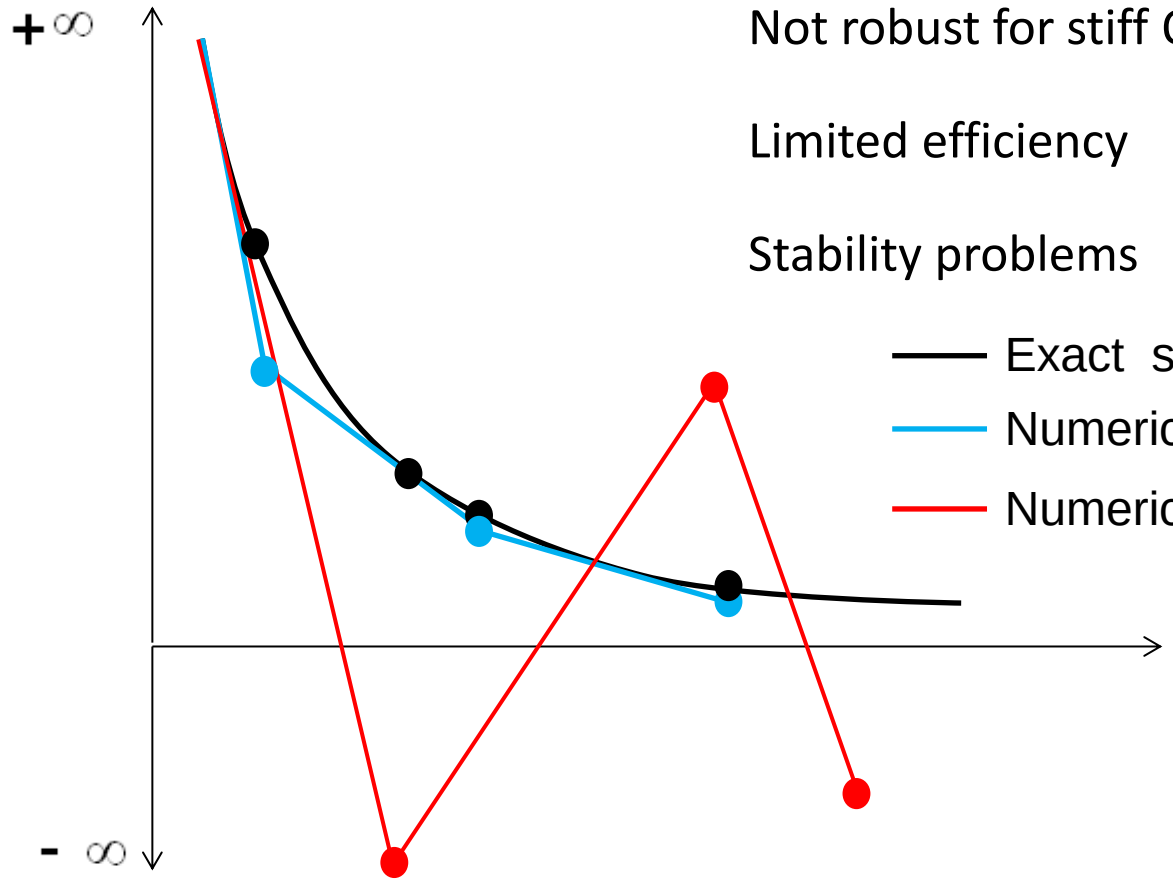
Traditional calculation schemes



Not robust for stiff ODEs

Limited efficiency

Stability problems

Exact solution

Numerical stable

Numerical unstable

$$\frac{dC}{dt} = f(k, C, \dots)$$

$$C_{t+\Delta t} = a_1 * C_t + source$$

A quasi-analytical solution scheme

leads to stable and consistent numerical results

Stability & consistency

Time step, residence time and decay rate

Quasi-analytical solution scheme

Dynamic integration of the reaction
(into mass balance equation)

$$C_{t+\Delta t} = C_t \exp\left(\frac{-\Delta t}{K_{res,pol}}\right) + \left(C_{in,t+\Delta t} * \frac{K_{res,pol}}{t_{res}} + m * K_{res,pol}\right) * \left[1 - \exp\left(\frac{-\Delta t}{K_{res,pol}}\right)\right]$$

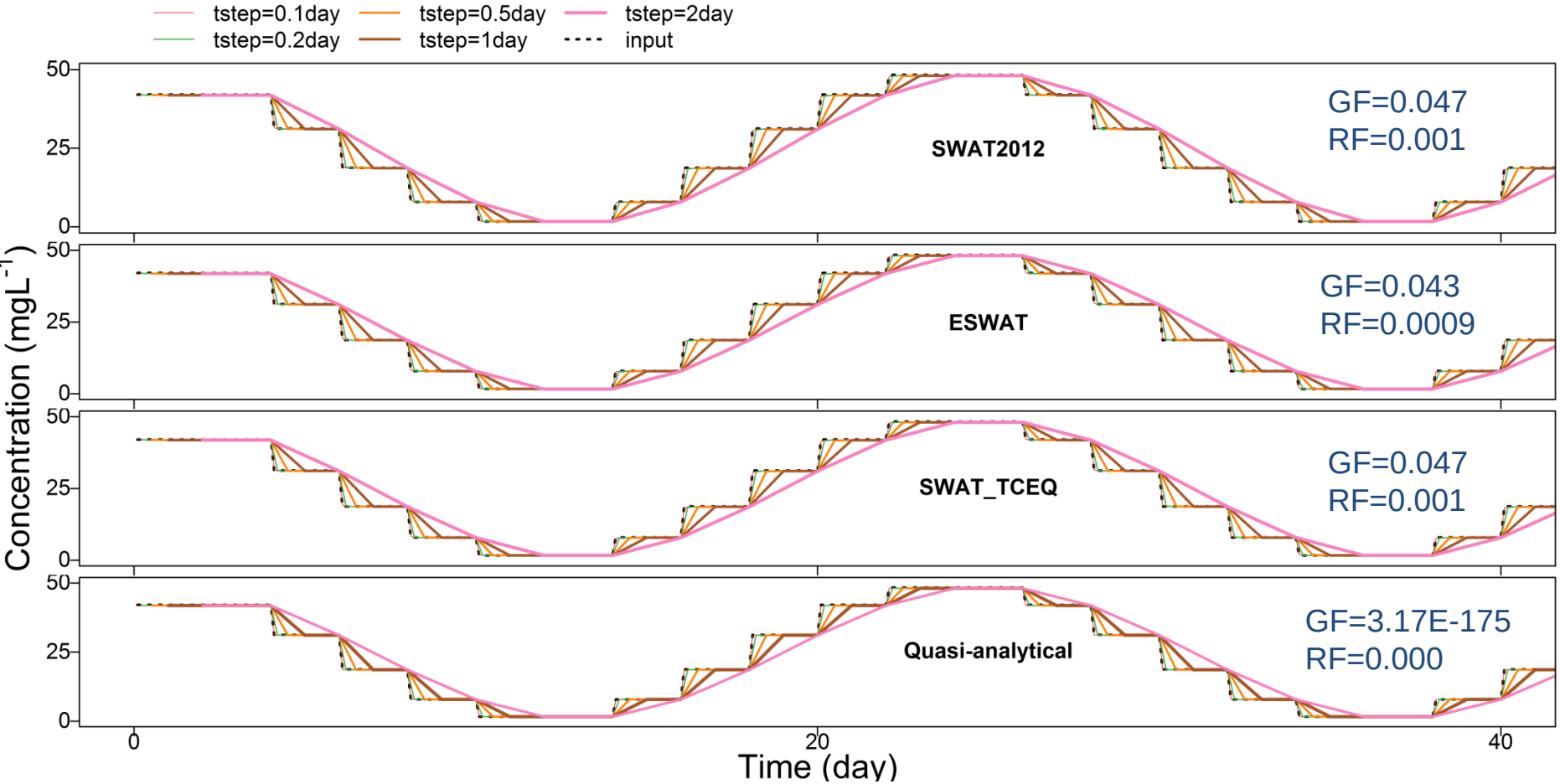
Test stability and robustness

Compare with other solution schemes

A quasi-analytical solution scheme

leads to stable and consistent numerical results

E.g. rapid flow/fine spatial discretization



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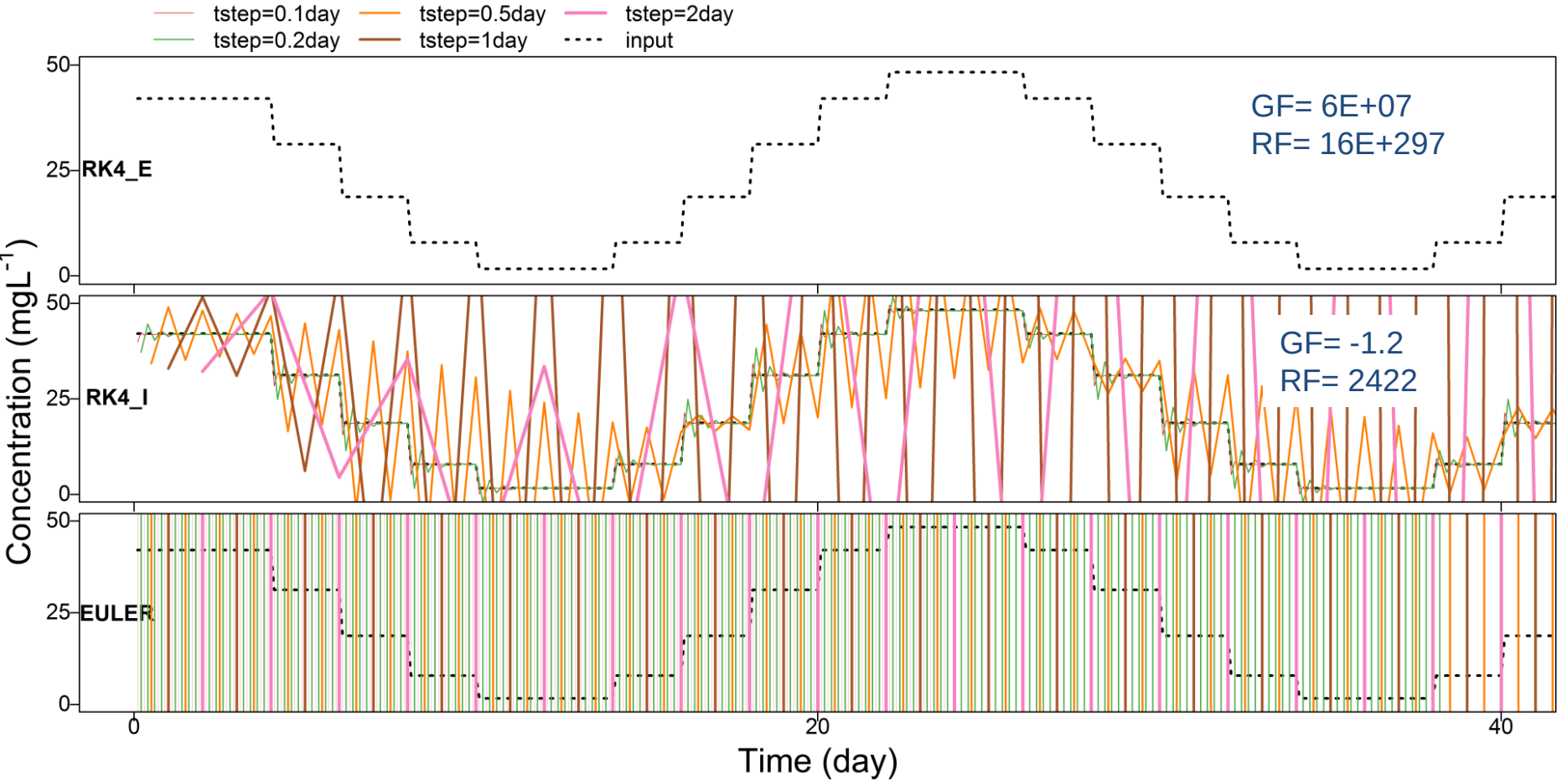
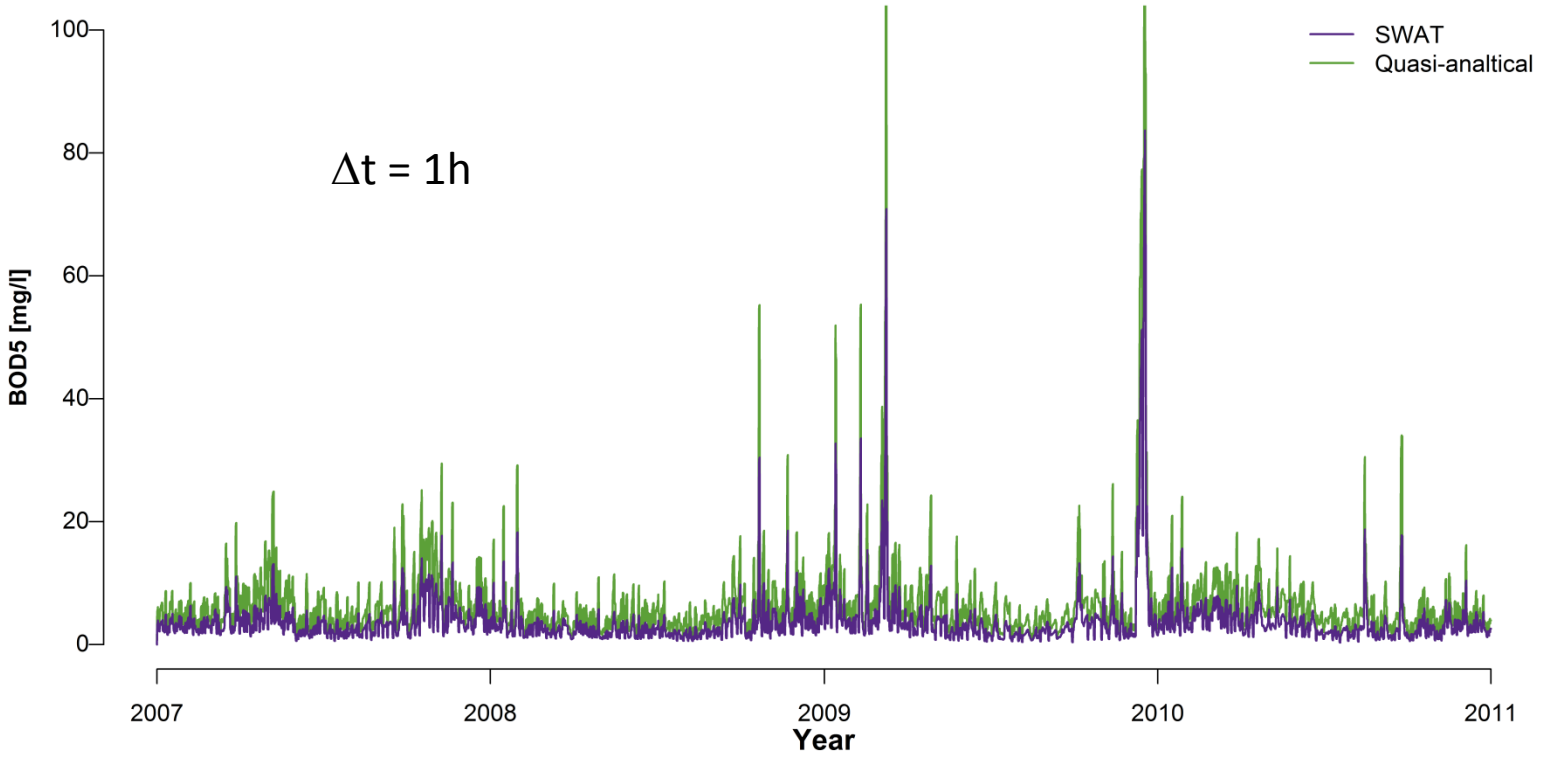


A quasi-analytical solution scheme

leads to stable and consistent numerical results

e.g. real case BOD5 simulation



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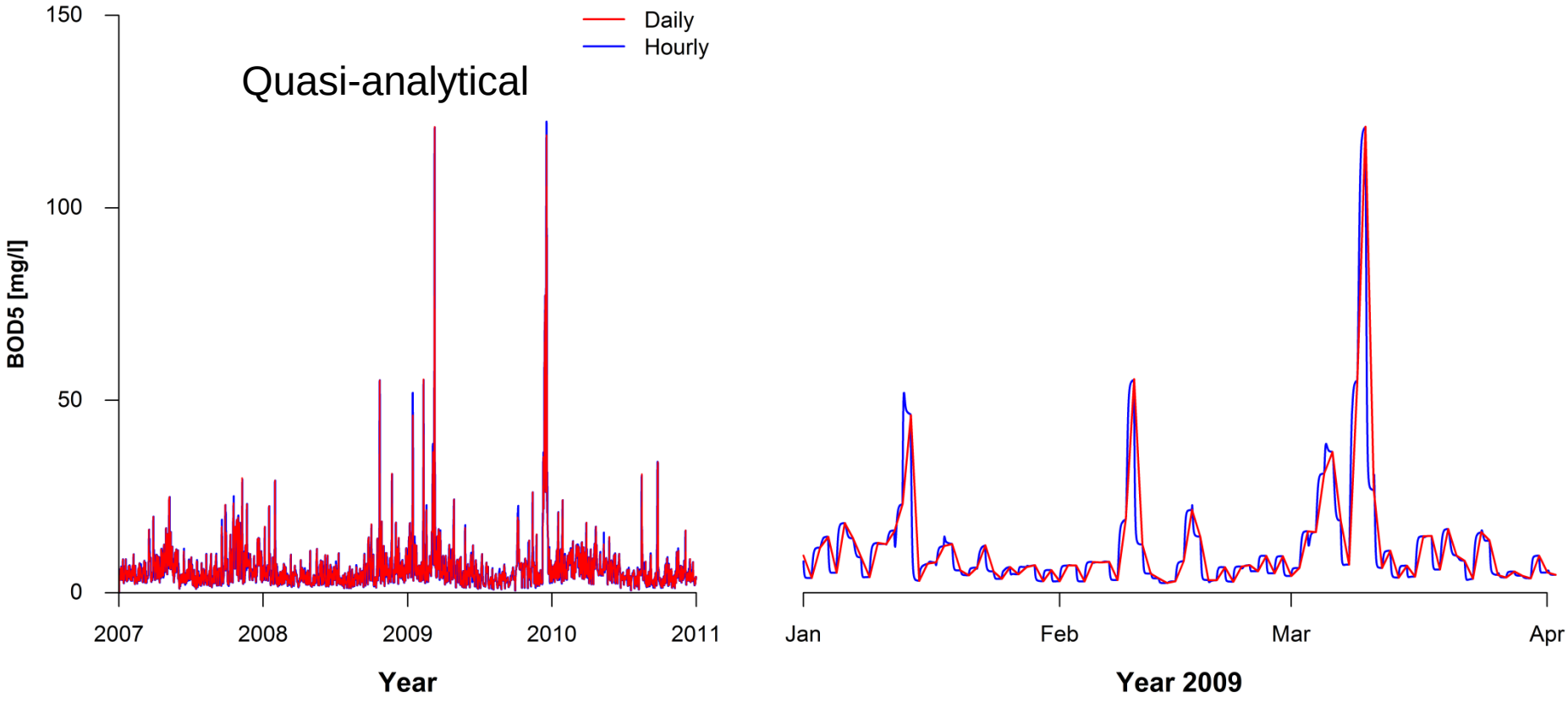

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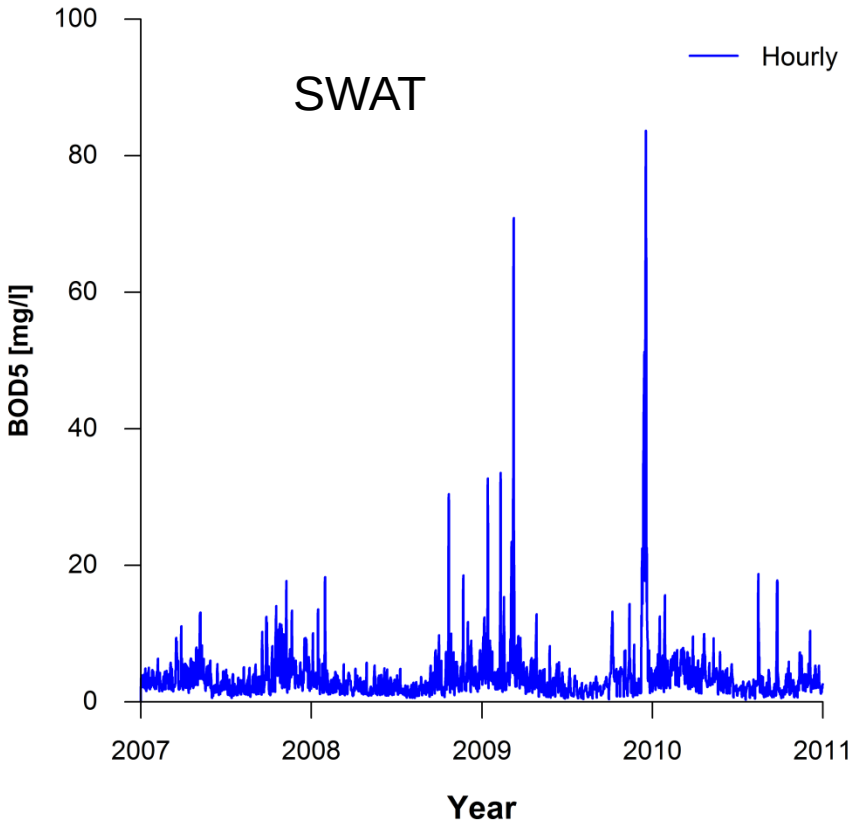

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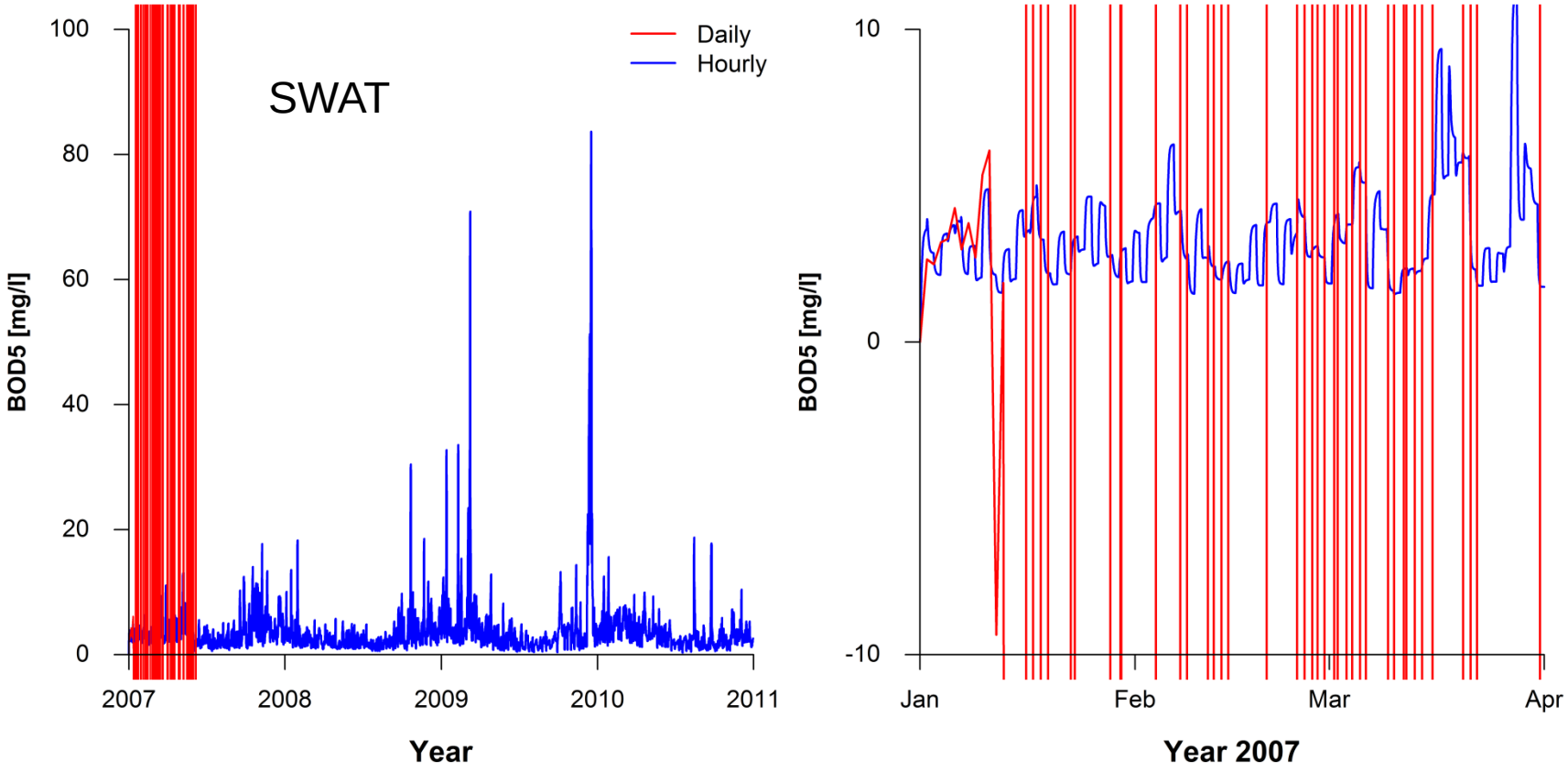

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provides an adequate representation without detailed hydrodynamic calculations

The Conceptual Integrated Tool for WQ Assessment

can be applied for simulations in complex networks and for reverse flows

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Representation of sediment movement

- Important for sediment-bound pollutants
- Difficult without hydrodynamics

PDF for Particle Size Distribution (PSD)

- Mobility depends on bed shear stress and PSD

Incipient motion of (nonuniform) sediment

- Based on Hjulström-Sundborg-Miedema diagram
- Dimensionless expression

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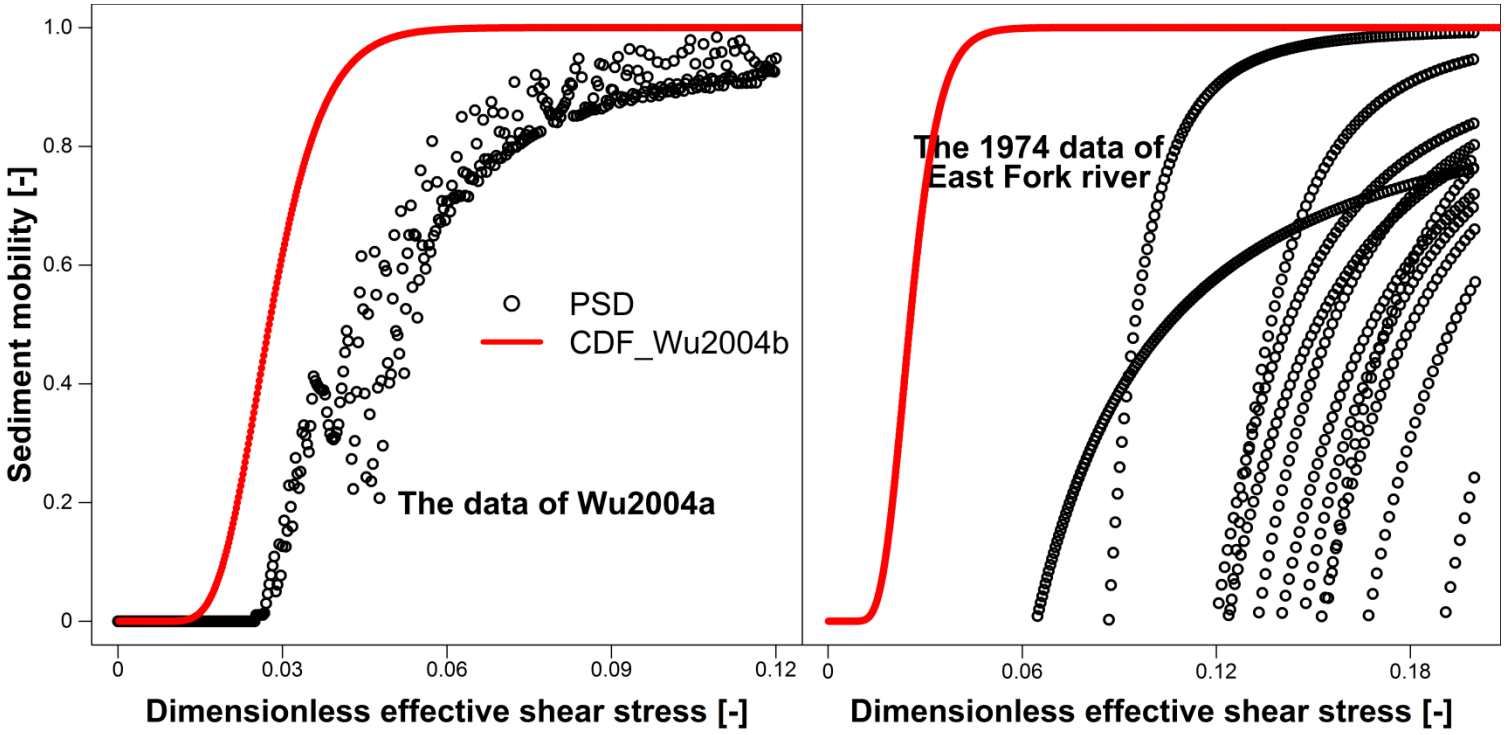
Traditional uniform distribution



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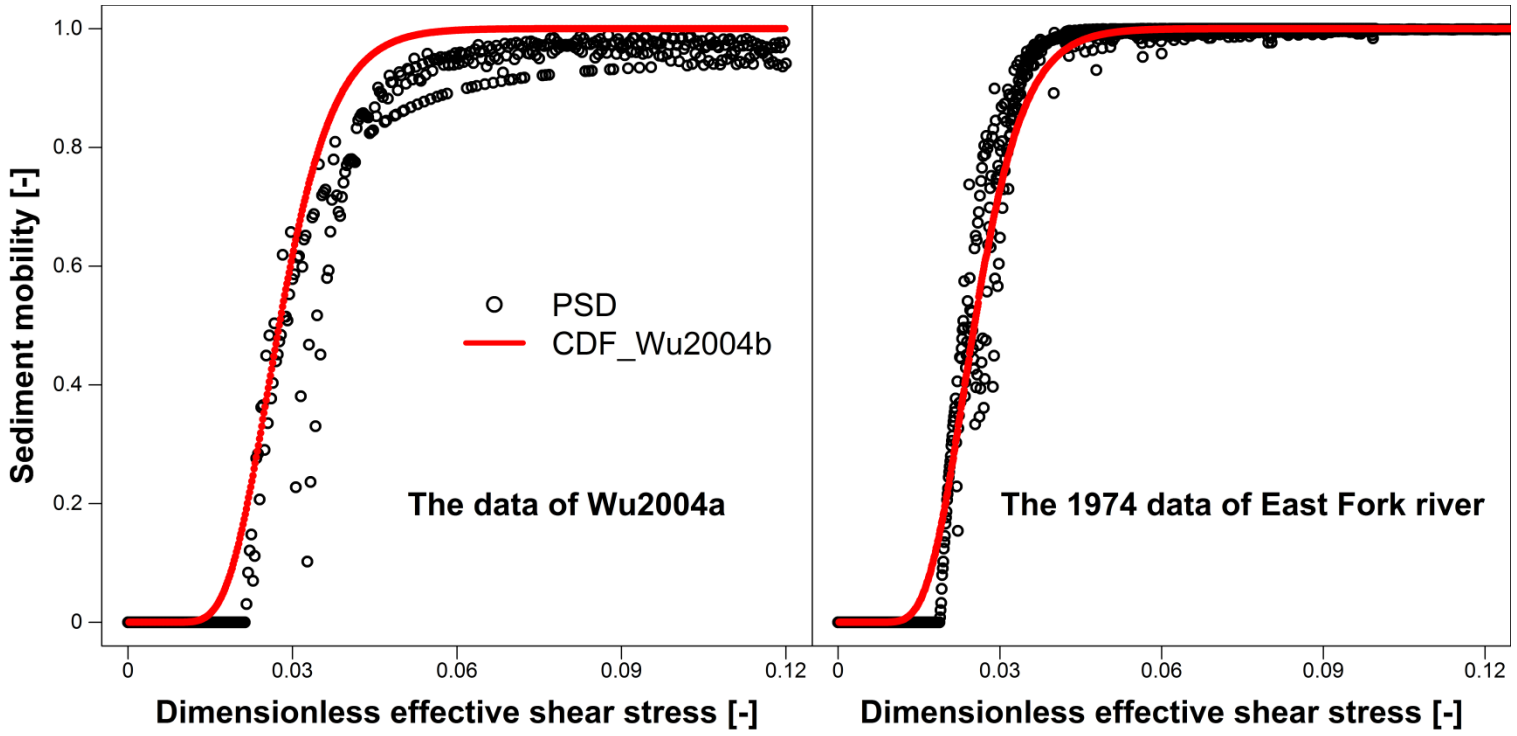
PSD based approach



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CIToWA

Integrates

- quasi-analytical scheme
- sediment simulator
- Qual2E equations (DO, BOD, N & P)

CSTR assumption for the reaches

Requires flow, depth, velocity and boundaries

How to handle complex networks & reverse flows?

Tidal zones, flood plains, sewer systems,…

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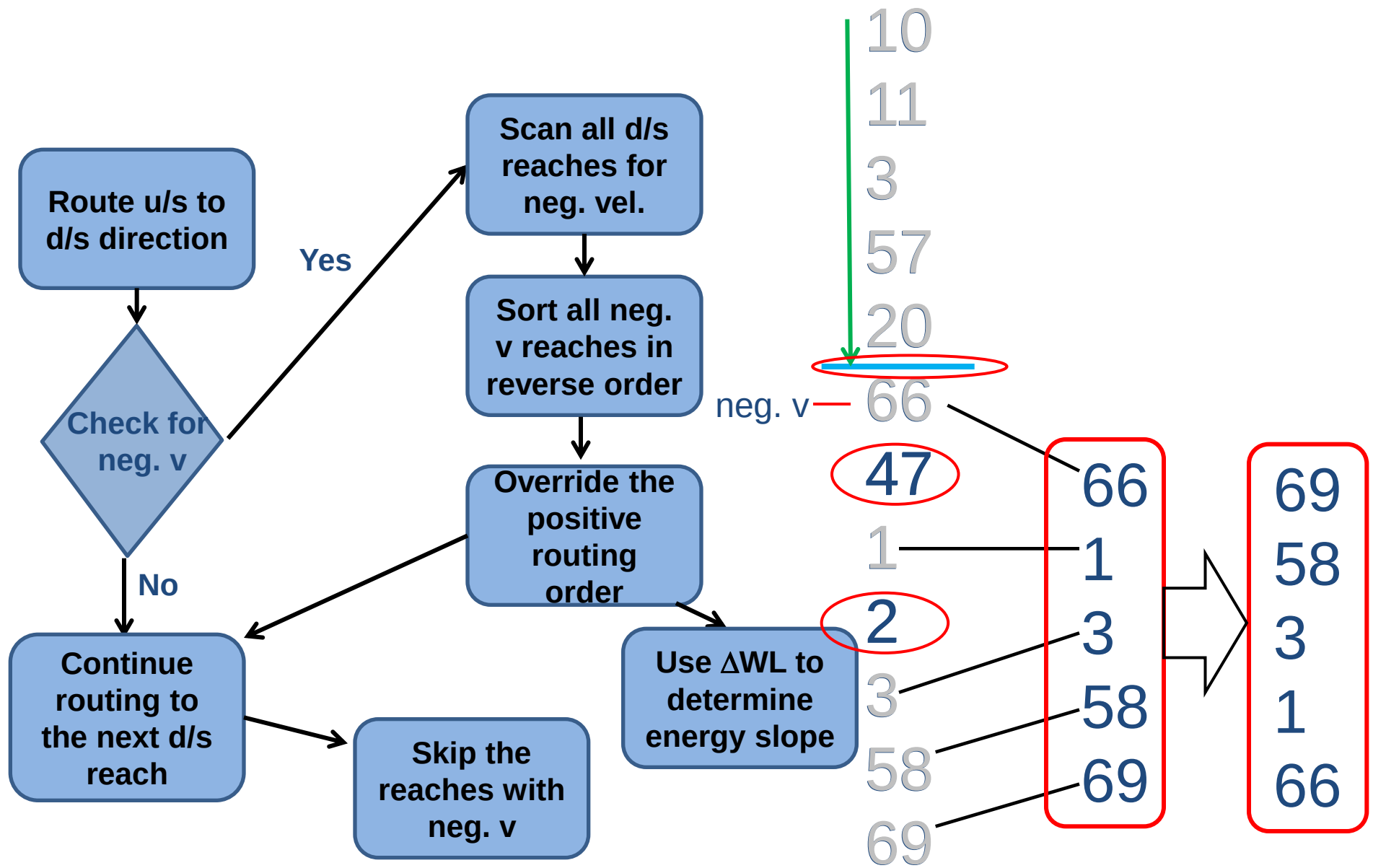

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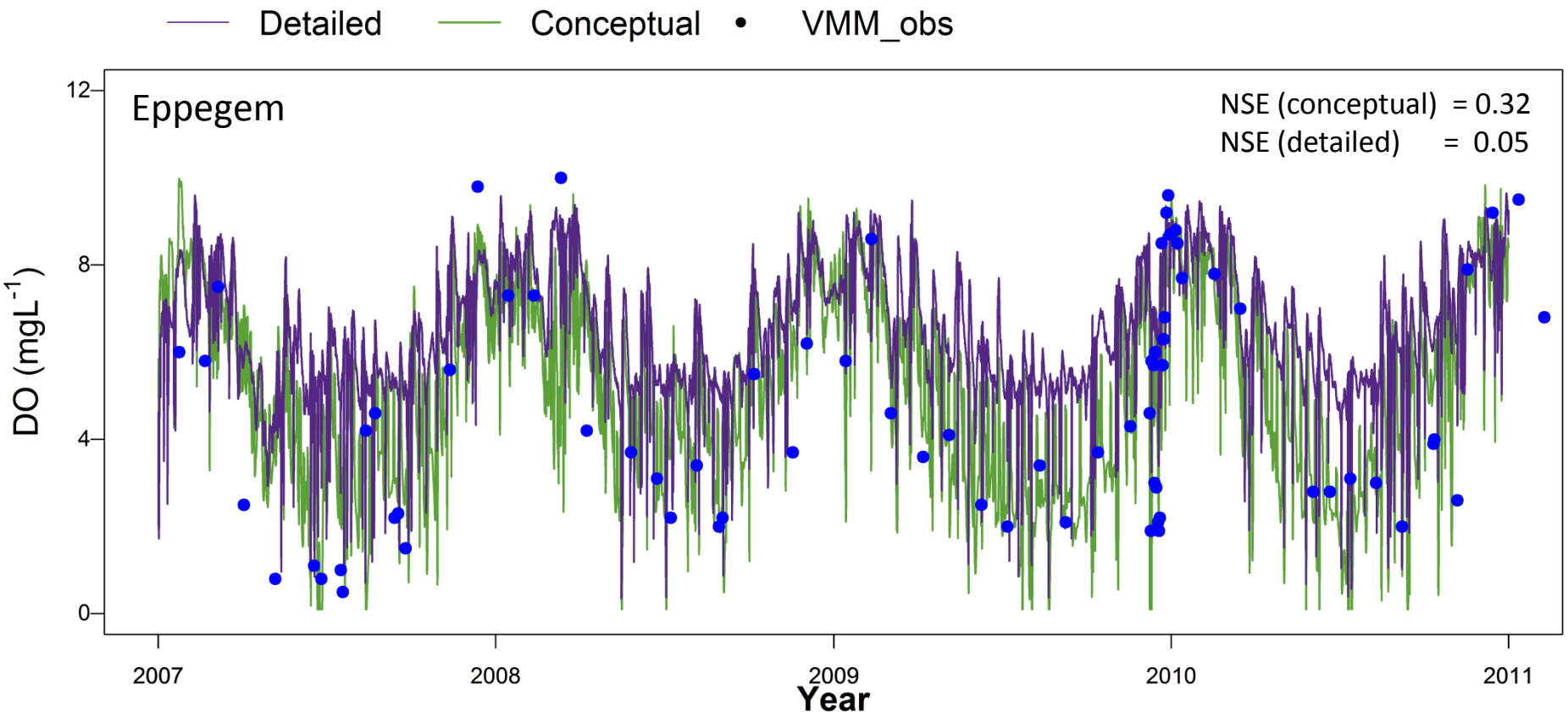
Case study of the River Zenne



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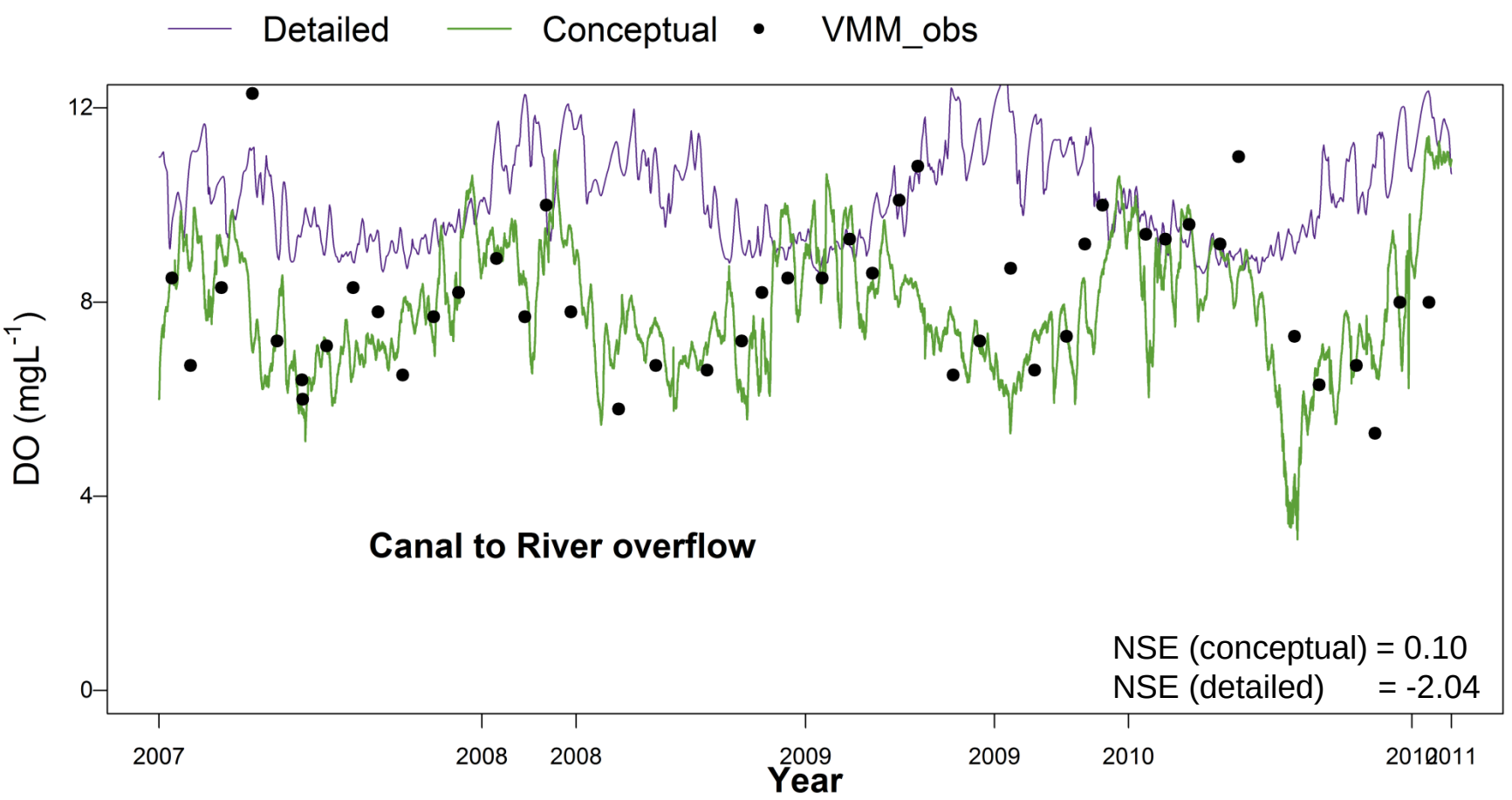

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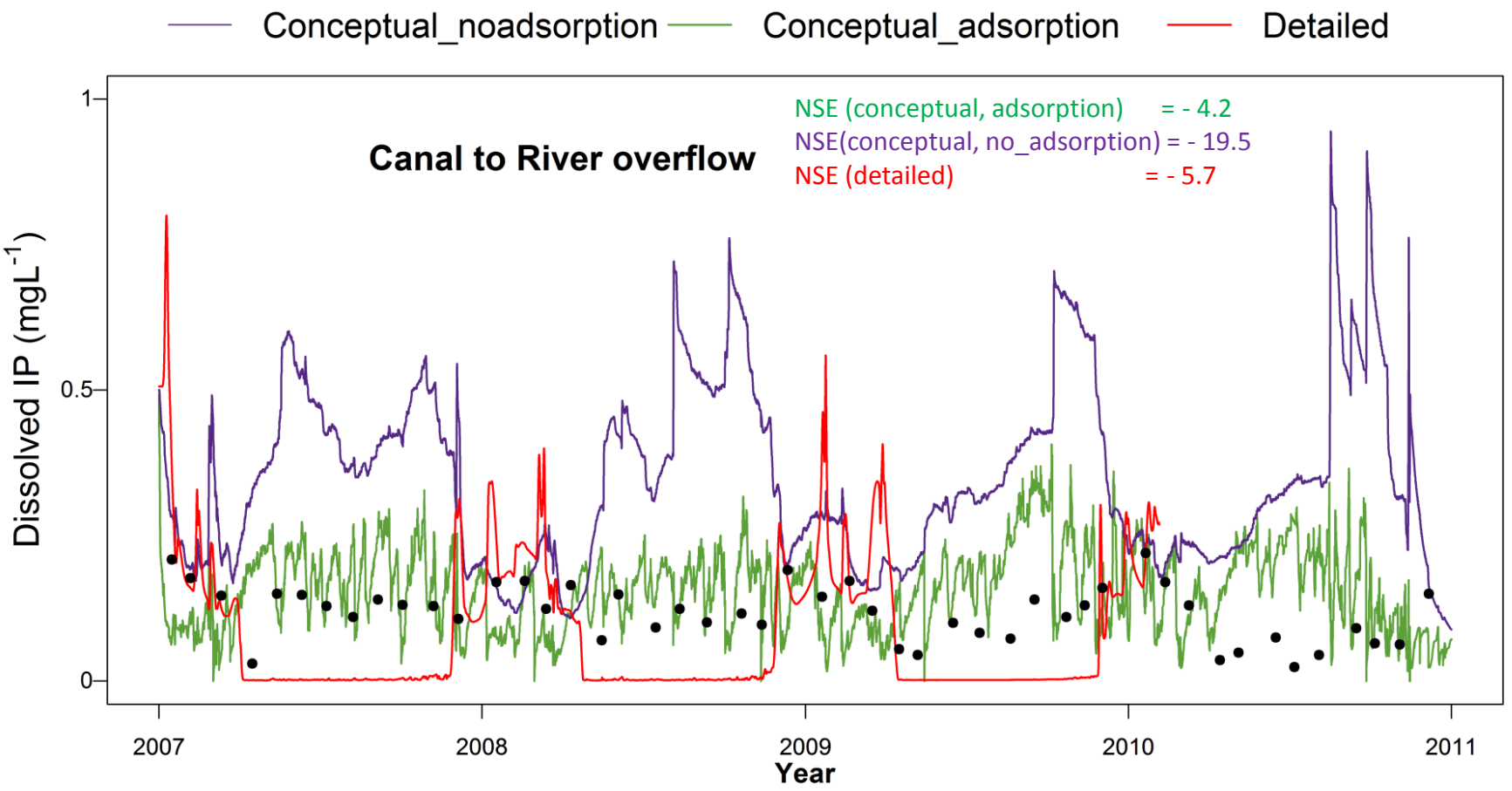

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CIToWA outperforms detailed model

Faster (>10 000 faster)

Better performance

Due to more efficient calibration

Allows for sensitivity and uncertainty analysis

Applicable for tidal rivers

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