EGU 2022 DISPLAY MATERIAL

Wed, 25 May 2022

This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

Improving the identifiability of Transient Storage Model parameters to explore process information in solutes breakthrough curve

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HYDRO CSI DOCTORAL TRAINING UNIT

TU WIEN TECHNISCHE UNIVERSITÄT WIEN

Vienna Doctoral Programme on Water Resource Systems

Why do we care?

Solute transport
in streams

Where does the water go?

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Where does the water go?

Control stream water quality in
river network

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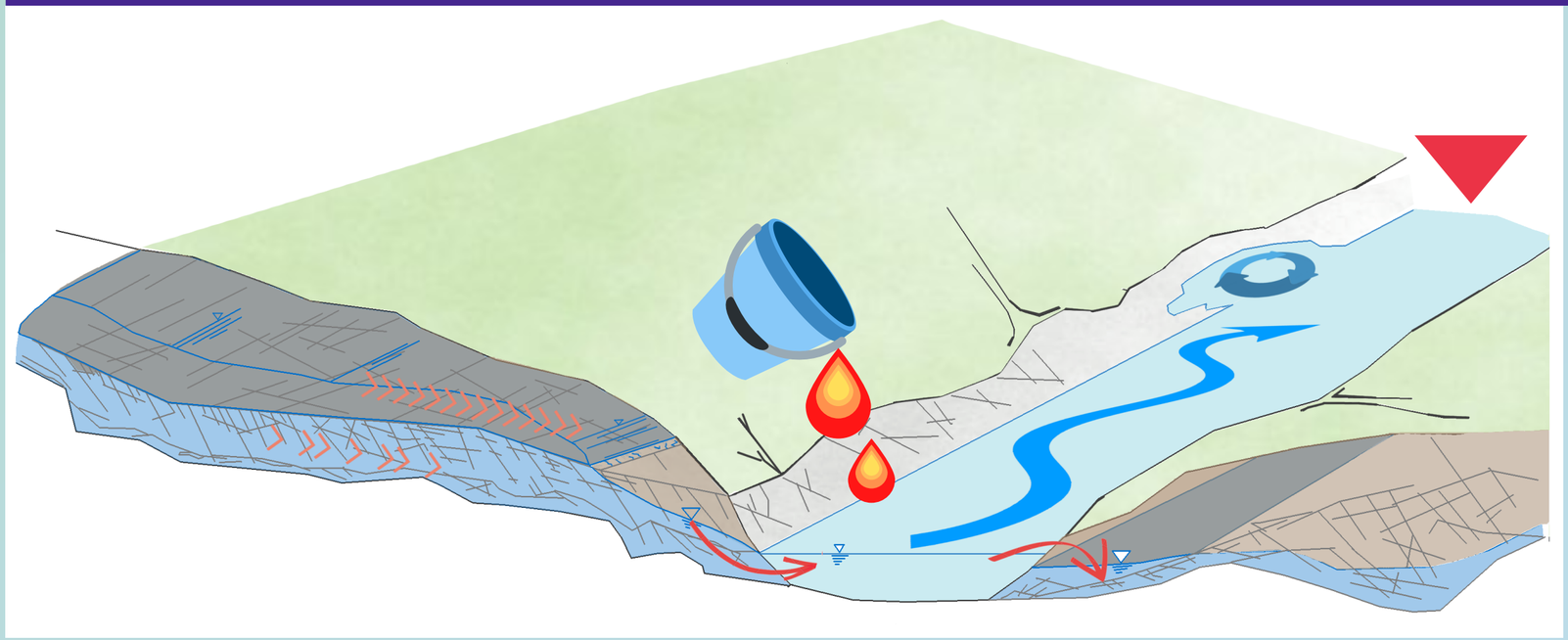
How do we experimentally study solute transport in streams?



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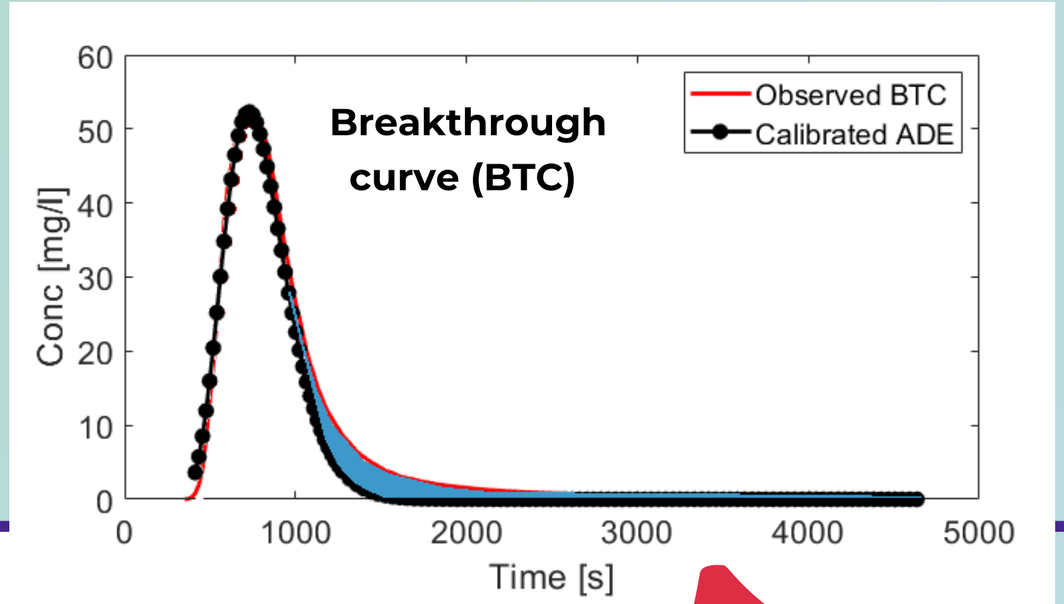

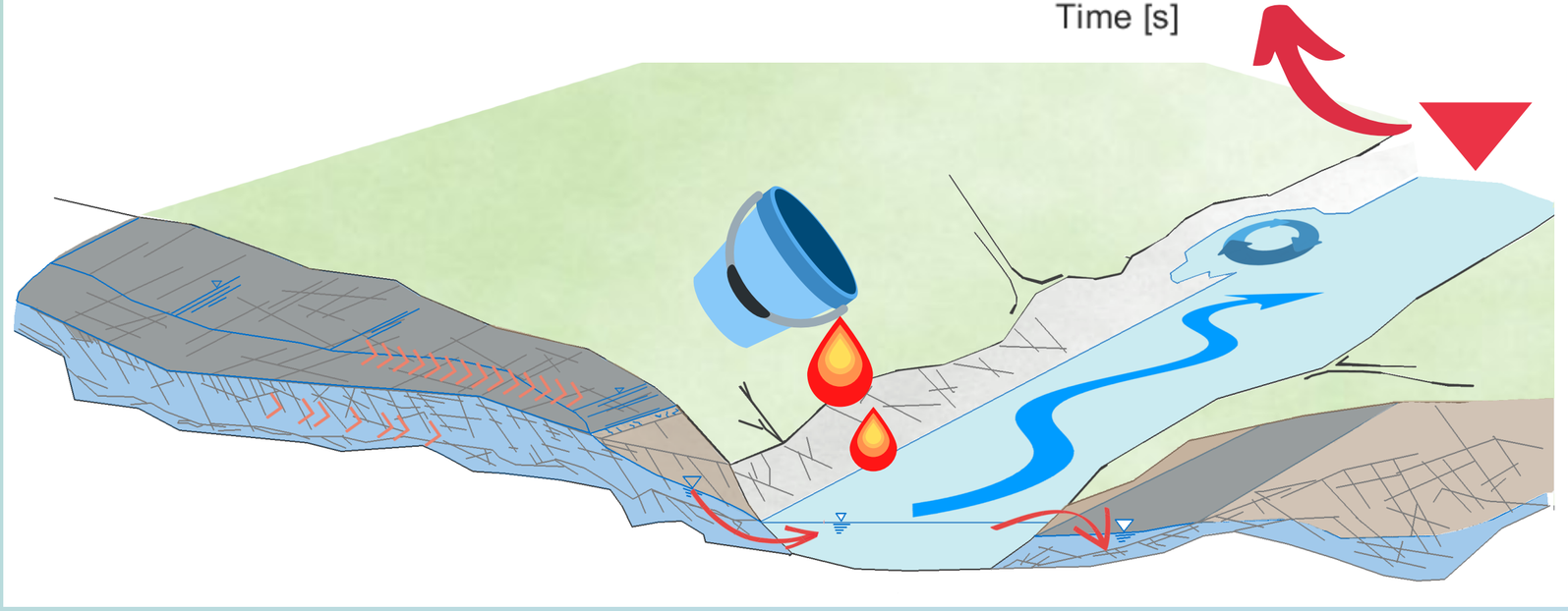

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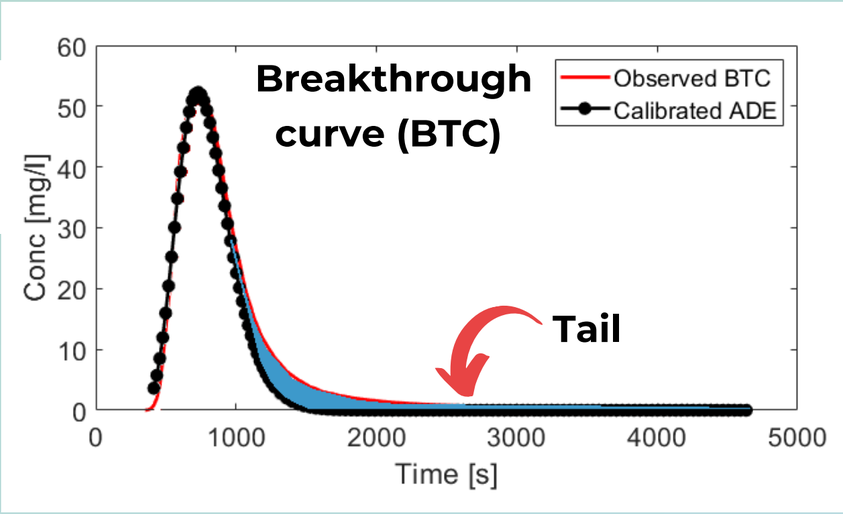
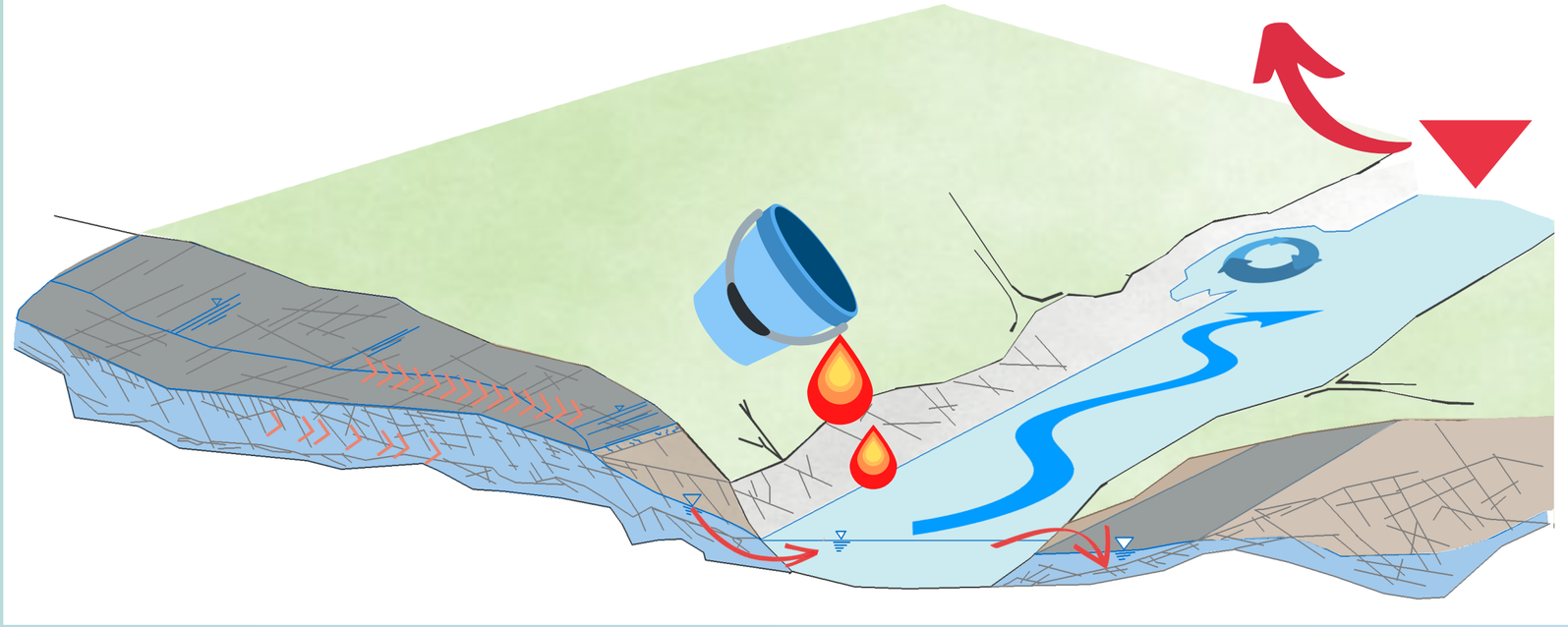
Advection Dispersion Equation

$$\frac{\partial C}{\partial t} = -v\frac{\partial C}{\partial x} + \frac{1}{A}\frac{\partial}{\partial x}\left(AD\frac{\partial C}{\partial x}\right)$$

Taylor (1921, 1954)

Advection dispersion Equation is non able to correctly describe the observed tracer transport in stream channels due to pronounced tail of the BTC





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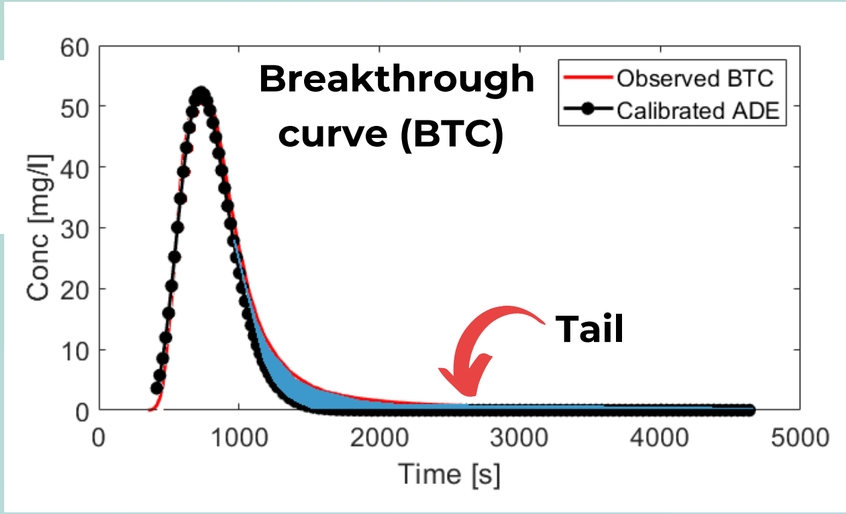
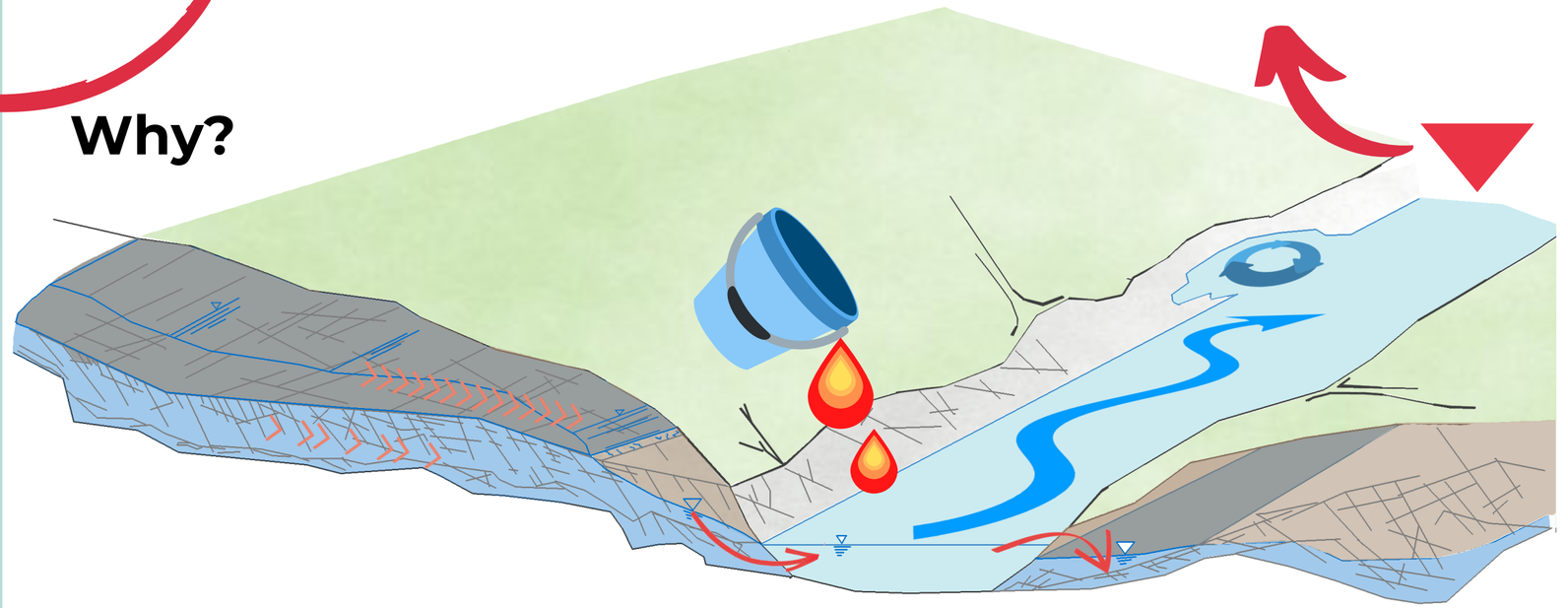


Why?



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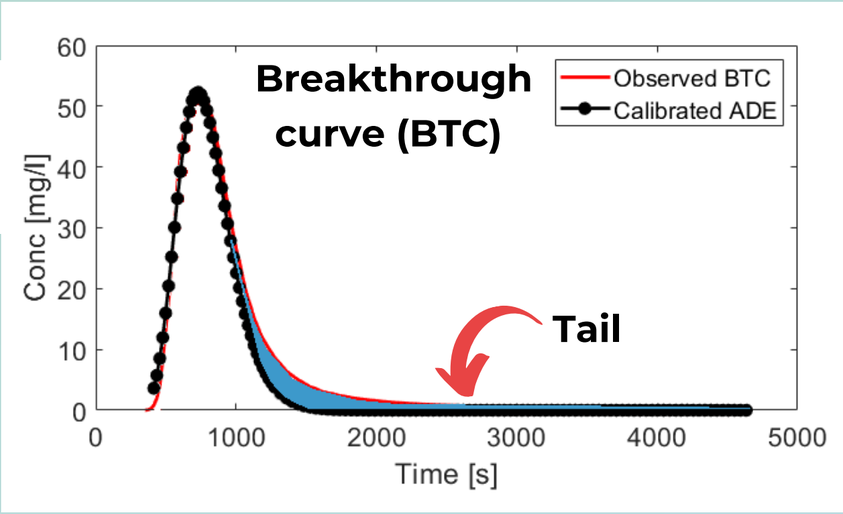
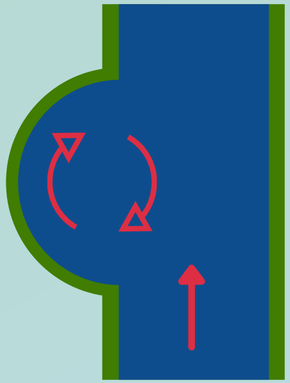


The stream is not a pipe!
Bencala (1993)

Hydrologic exchange with:

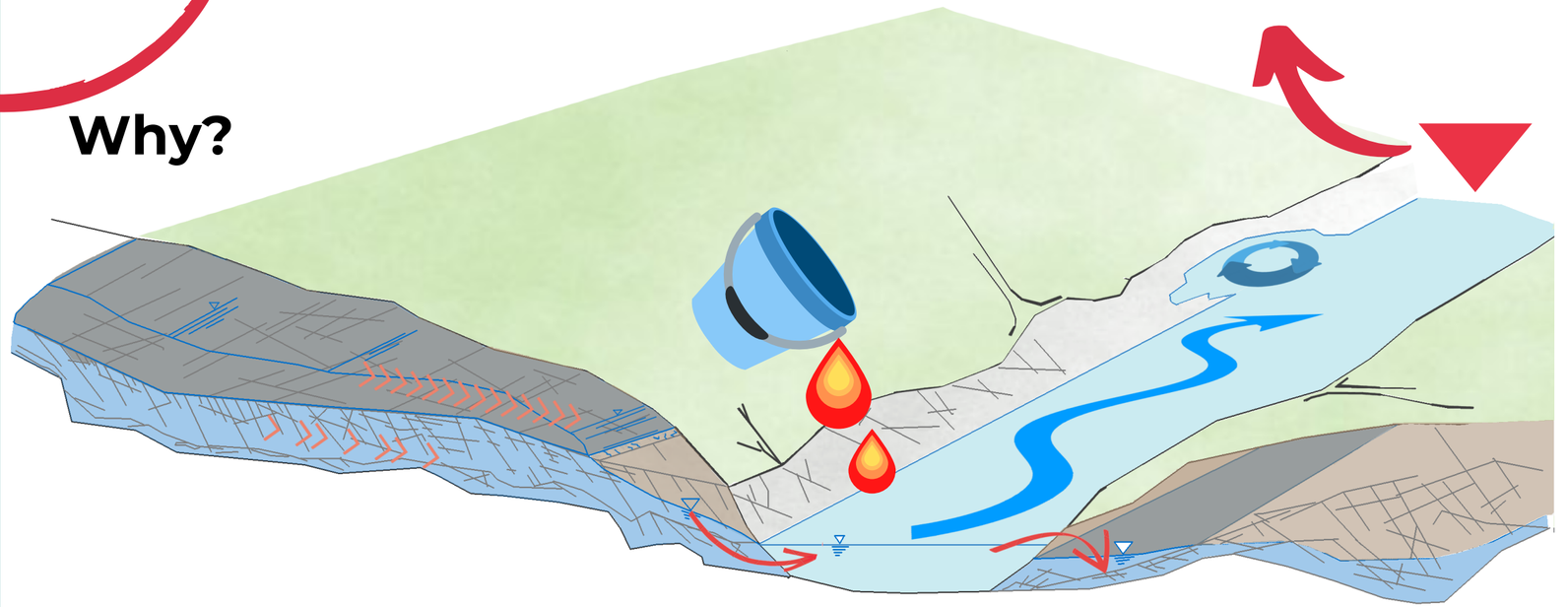
In-stream sediments

Pools



SW-GW exchange

Why?



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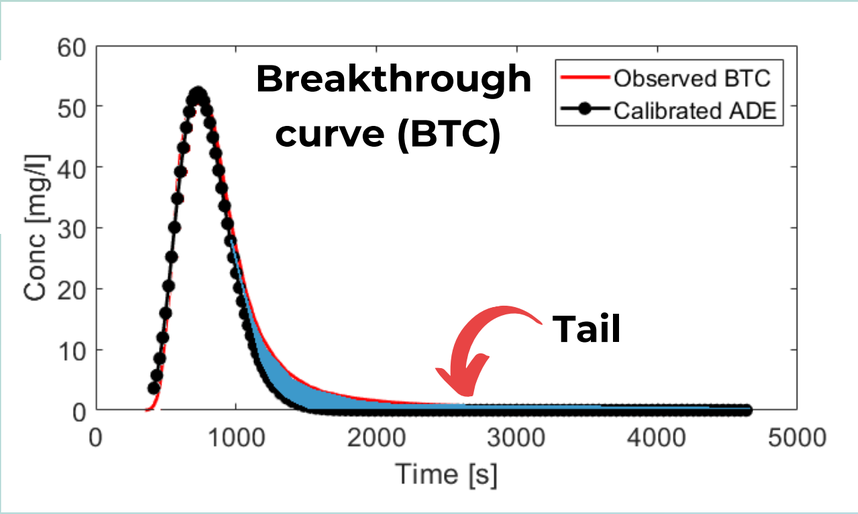
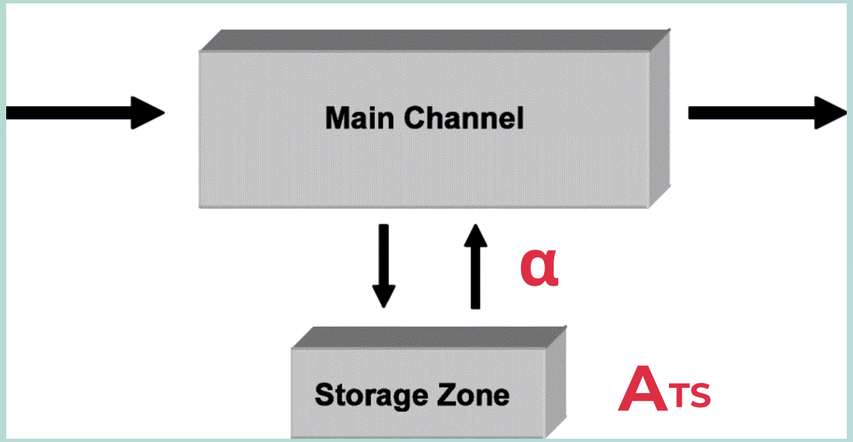
Transient storage model (TSM)

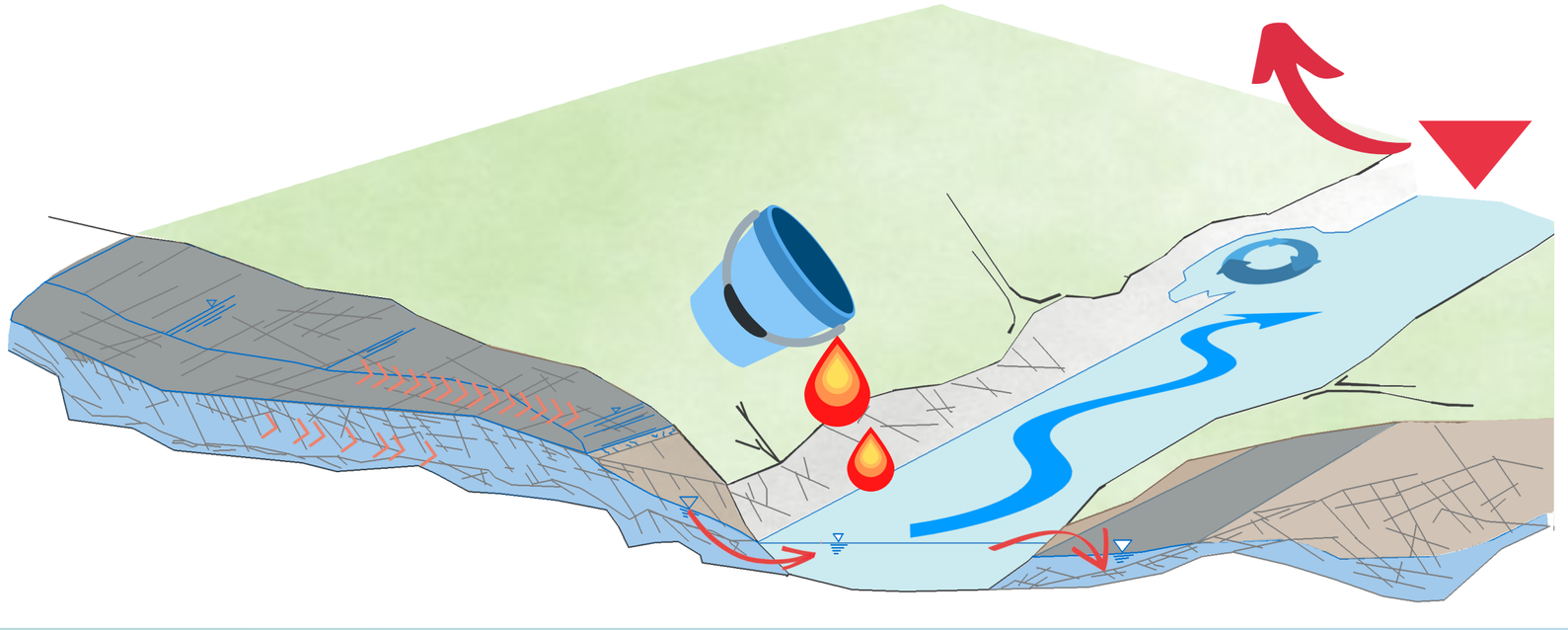
$$\begin{cases} \frac{\partial C}{\partial t} + \frac{Q}{A}\frac{\partial C}{\partial x} = \frac{1}{A}\frac{\partial}{\partial x}\left(AD\frac{\partial C}{\partial x}\right) + \alpha(C_S - C) \\ \frac{dC_s}{dt} = \alpha\frac{A}{A_s}(C - C_S) \end{cases}$$



We can model the hydrologic exchanges that cause solute delay in the stream channel



Bencala (1983) and Bencala and Walters (1983)



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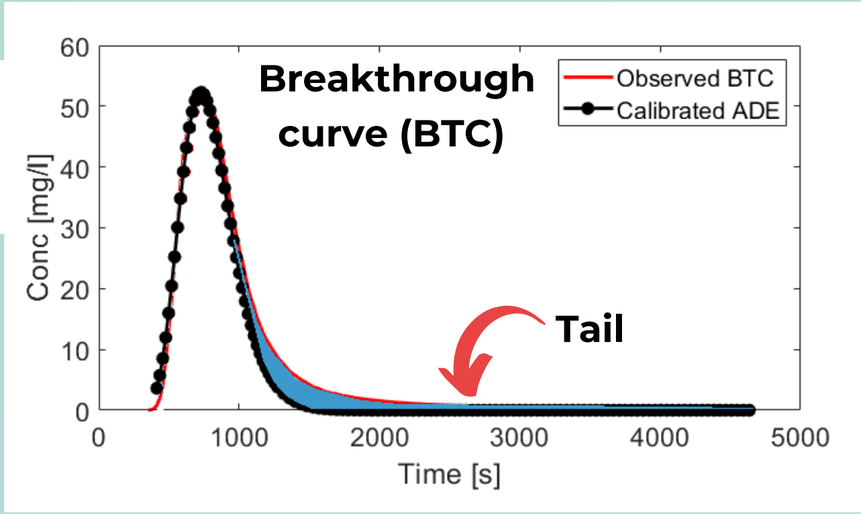
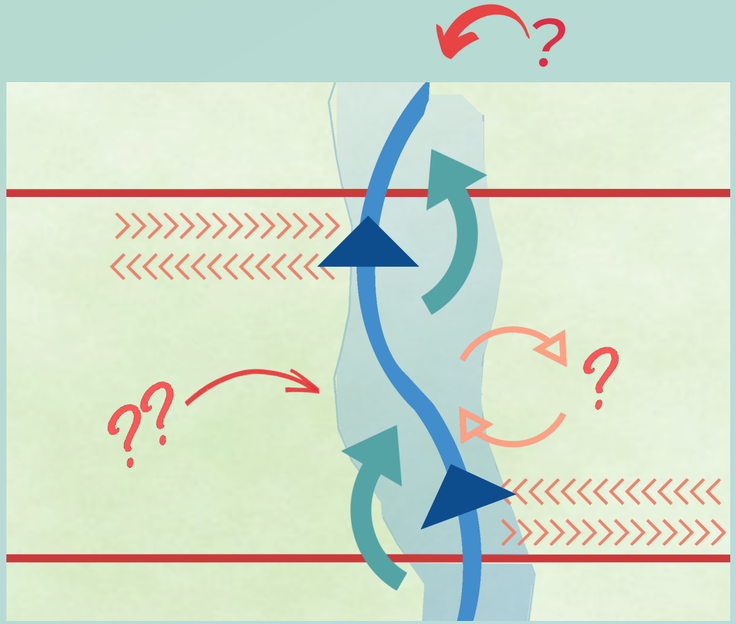




Despite what we know

Do our modelling have a physical meaning?

We still have **inconsistent understanding** of water/solute exchange in the stream corridor; **We are uncertain about the information content of the measurement and what TSM parameter indicate** (Ward and Packman, 2019).

Contradicting results

Interpretations of the physical phenomenon via TSM is based on few parameters, with no focus on their **uncertainty**, and **reliability** (Knapp and Kelleher, 2020) -> **Non-identifiability**

Non-identifiability in TSM

That's not a small detail...

199 © IWA Publishing 2002 Journal of Hydroinformatics | 04.3 | 2002

WATER RESOURCES RESEARCH, VOL. 49, 1184–1188, doi:10.1002/wrcr.20103, 2013

Dynam
model
Thorsten

WATER RESOURCES RESEARCH, VOL. 49, 5290–5306, doi:10.1002/wrcr.20413, 2013

Influen
on para
stream
Adam N.
Received 9 A

Identifiability of transient storage model parameters along a mountain st
C. Kelleher,[1,3]
Received 15 October

A software tool to assess uncertainty in transient-storage model
Adam S. Ward
Neil McIntyre

Exploring Tracer Information and Model Framework Trade-Offs to Improve Estimation of Stream Transient Storage Processes

Christa Kelleher[1,2], Adam Ward[3], J. L. A. Knapp[4,5], P. J. Blaen[6,7], M. J. Kurz[8,9], J. D. Drummond[10], J. P. Zarnetske[11], D. M. Hannah[6], C. Mendoza-Lera[12,13], N. M. Schmadel[3,14], T. Datry[12], J. Lewandowski[15], A. M. Milner[6], and S. Krause[6,7]

Alpha and A_TS are often non-identifiable!

Non-identifiability in TSM

That's not a small detail...

Since α and A_TS are uncertain and they are supposed to describe the tail of the BTC...

Shall we really keep looking at the tail?
Are we missing the focus?
Do we need to change our approach?

Water Resources Research

COMMENTARY
10.1029/2019WR026257

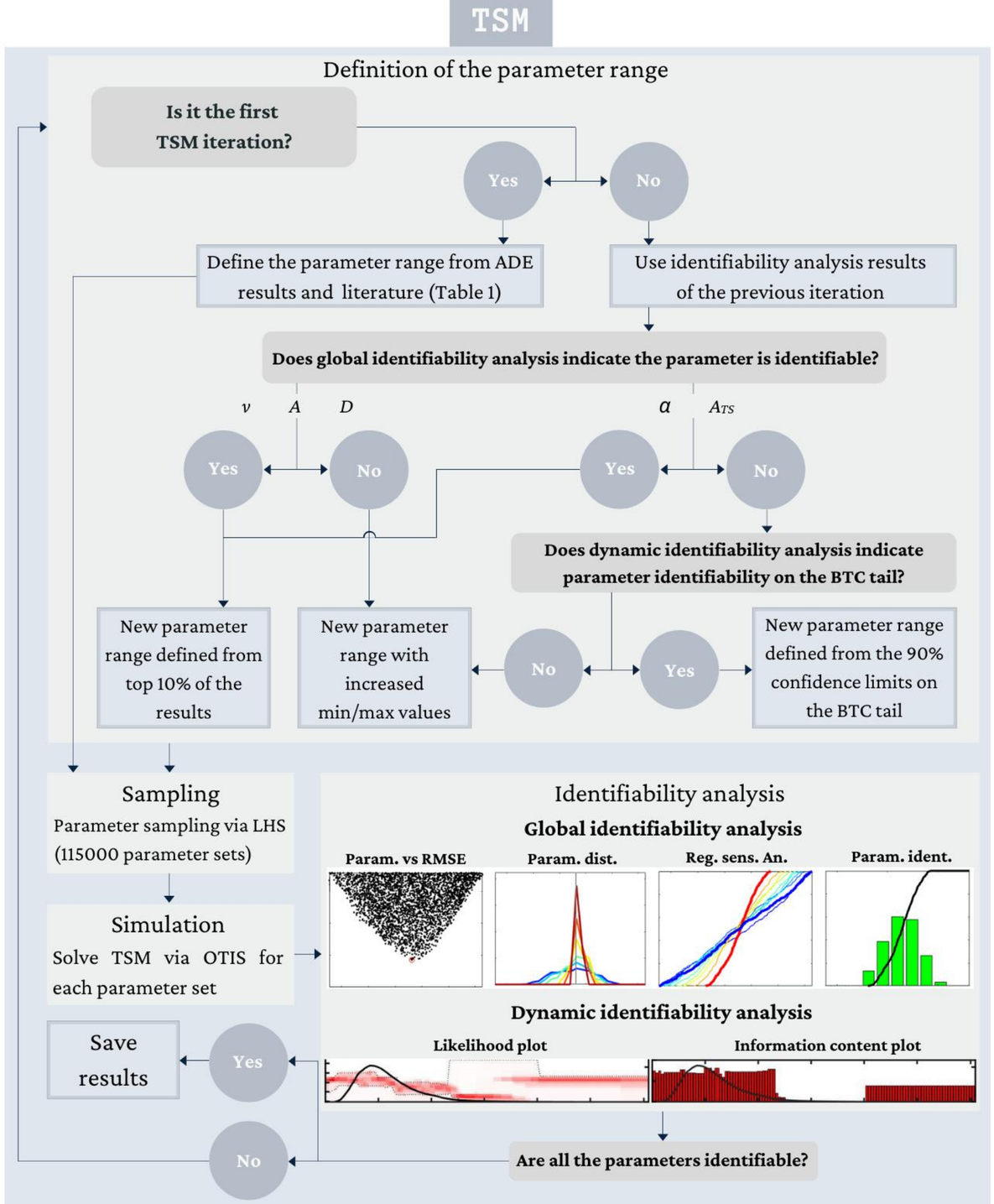
Julia L.A. Knapp and Christa Kelleher contributed equally to this work.

A Perspective on the Future of Transient Storage Modeling: Let's Stop Chasing Our Tails

Julia L.A. Knapp[1] and Christa Kelleher[2]

[1]Department of Environmental Systems Science, ETH Zurich, Zurich, Switzerland, [2]Department of Earth Sciences, Syracuse University, Syracuse, NY, USA

How can be sure of physical interpretation of TSM parameters if Alpha and A_TS are non-indentifiable?



Our approach

For every BTC:

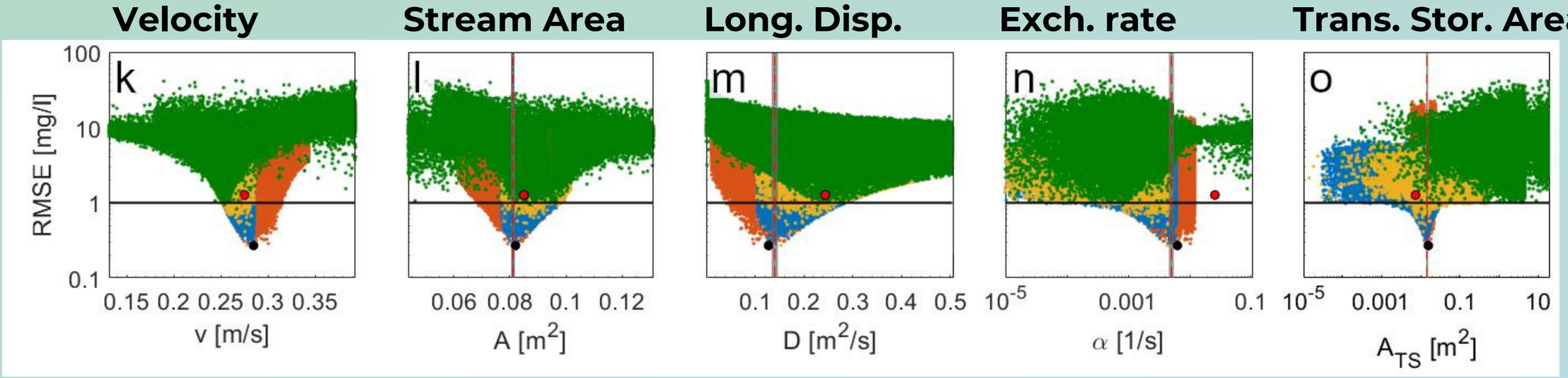
We start defining the parameter range from: Literature and ADE modelling OR results from previous iteration

We sample from the parameters' space 115'000 parameter sets via Latin Hypercube Sampling

We run TSM and perform global parameter sensitivity analysis and dynamic sensitivity analysis

We use these results to define the most sensitive parameter space and, for Alpha and A_TS, their identifiability range on the tail of the BTC

Results



Each iteration included 115'000 parameter sets.

1st iteration

2nd iteration

3rd iteration

4th iteration

v, A, D:
The most sensitive parameter range (lower RMSE) was targeted by the following iteration.

Alpha, Ats:
Identifiability of Alpha and Ats was investigated on the tail of the BTC.

Conclusions

1) Studying the identifiability of Alpha and A_TS on the tail of the BTC was pivotal to improve identifiability of TSM parameters;

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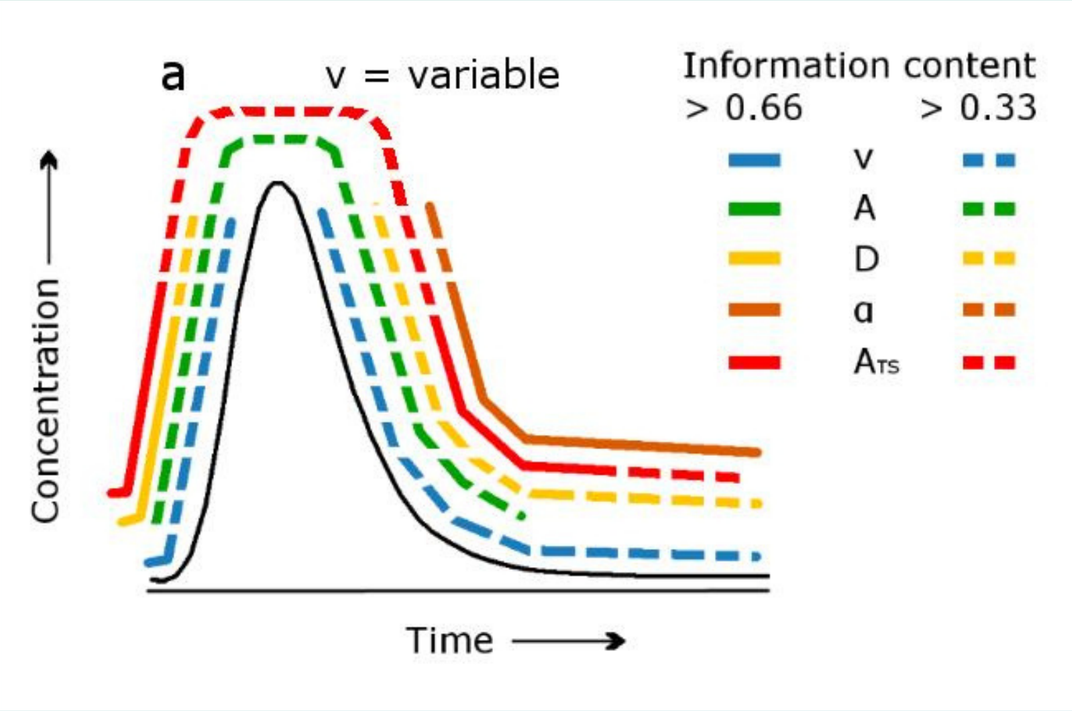
2) When identifiable, the TSM parameters control solute arrival-time and solute retention in stream channels;



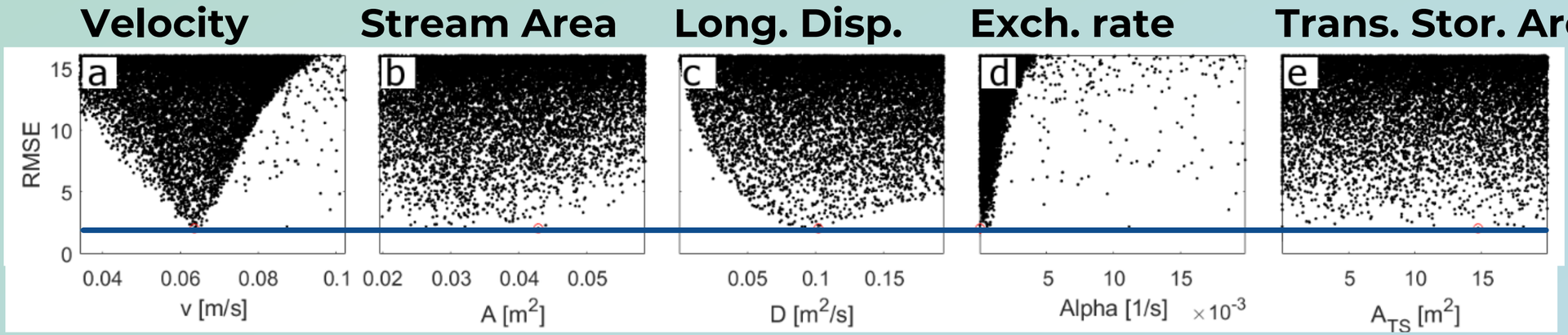
Parameter influence on the BTC

Conclusions

1) Studying the identifiability of Alpha and A_TS on the tail of the BTC was pivotal to improve identifiability of TSM parameters;

2) When identifiable, the TSM parameters control solute arrival-time and solute retention in stream channels;

3) The TSM mimics the ADE when one or more transient storage parameters is not-identifiable;



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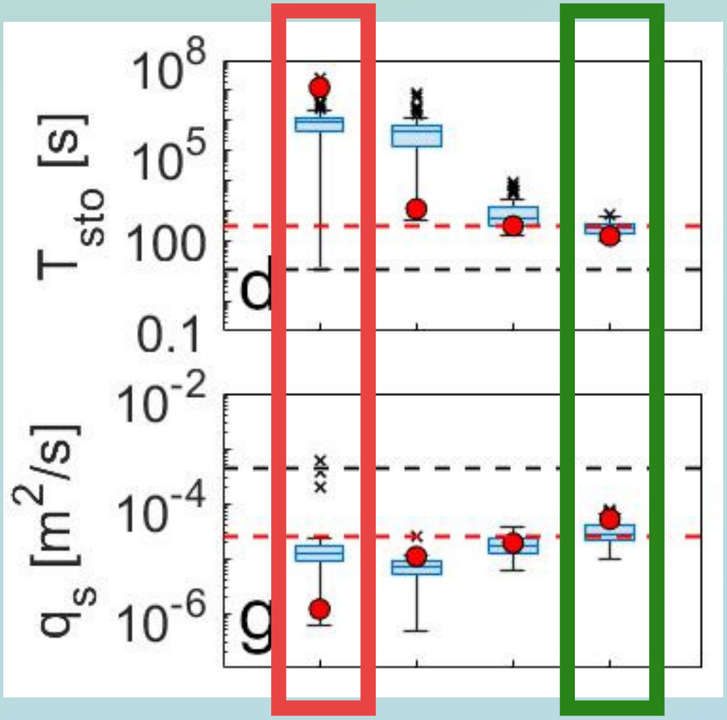
2) When identifiable, the TSM parameters control solute arrival-time and solute retention in stream channels;

3) The TSM mimics the ADE when one or more transient storage parameters is not-identifiable;

4) Non-identifiable parameters result in wrong estimation of the metrics describing solute transport in stream.



Metrics results after the 1st iteration

Metrics results after the 4th iteration

T_sto is the average time spent by a molecule in the transient storage zone (Thackston and Schnelle, 1970):

$Tsto = A\_TS/(\alpha A)$

q_s is the water flux through the storage zone per unit length of stream channel (Harvey et al., 1996):

$qs = \alpha A$

THANK YOU!

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Full paper under discussion at:
https://hess.copernicus.org/preprints/hess-2022-149/

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