Vegetation and flow rate impact on in-stream longitudinal dispersion and retention processes

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HYTECH Aquatic Interfaces

MARIE CURIE ACTIONS

Introduction

Objectives	Define influence of *vegetation* and *flow rate* on mixing and transport processes
Actions	Performed tracer tests in natural stream (Erpe) Evaluated parameters with the STIR coding
Findings	Effects of reach length on dispersion coeff. and storage zone parameters Impact of vegetation and flow rate on retention and mixing processes Importance of equipment (fluorometers)

Literature review (parameters)

Storage zone residence time		Longitudinal dispersion coeff.
Schmid et al. (AWR-2010) ↓	Flow rate ↑	↑ *Murphy et al. (WRR-2007)*
Bottachin-Busolin et al. (AWR-2011) ↑	Reach length ↑	↓↑ *Gooseff et al. (JH-2013)*
Harvey et al. (AWR-2003) ↑	Vegetation density ↑	↓ *Shucksmith et al. (WRR-2011)*

Continuous (step) injection provides more reliable parameter estimates. *(Wagner and Harvey, WRR-1997)*

Literature review (models)

- Transient Storage model (TSM)
  Bencala & Walters (1983)
  Runkel & Broshears (1991) – *OTIS* and *OTIS-P*
- Advection-dispersion-mass-transport equation (ADMTE)
  Huggerty et al. (2000)

Single storage zone analysis

- Solute Transport in Rivers (*STIR*)
  Marion et al. (2008)

Multiple storage zone analysis

What was done

- Tracer tests

  Performed in 2013 (Erpe stream, Germany)

- Equipment

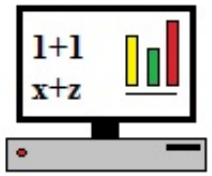
  Applied fluorometers with better detection characteristics

- Tracer test

  Conducted in 2014 (Erpe stream, Germany)

- Parameters

  Evaluated



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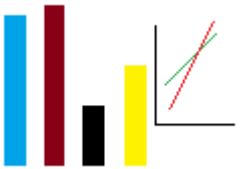

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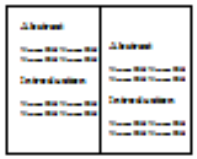
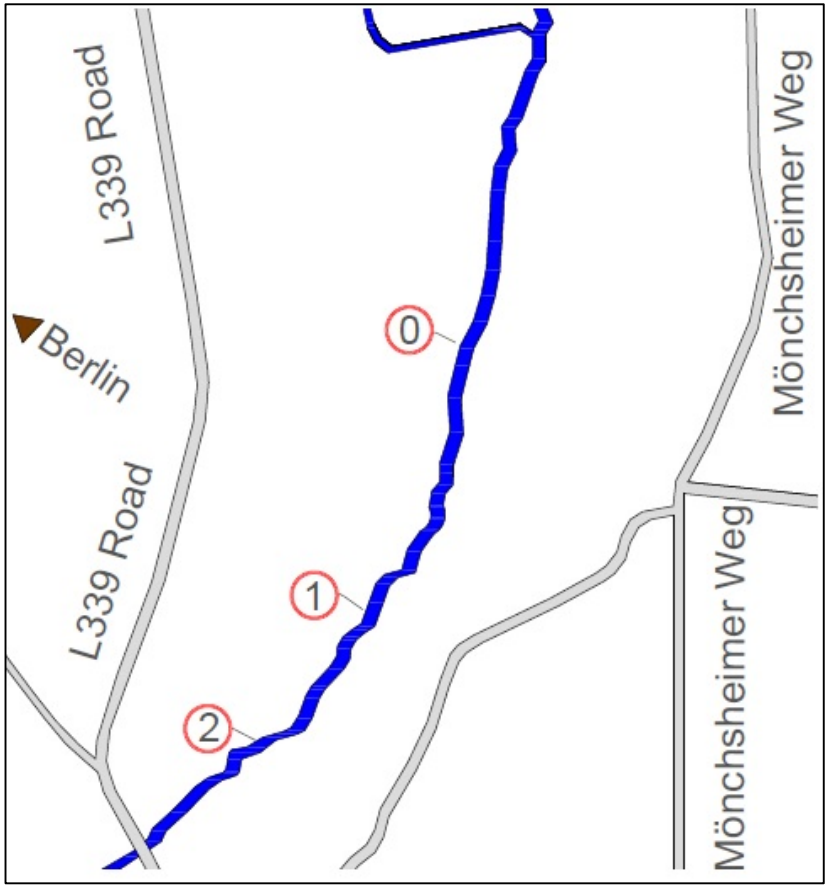


Erpe test (2013)

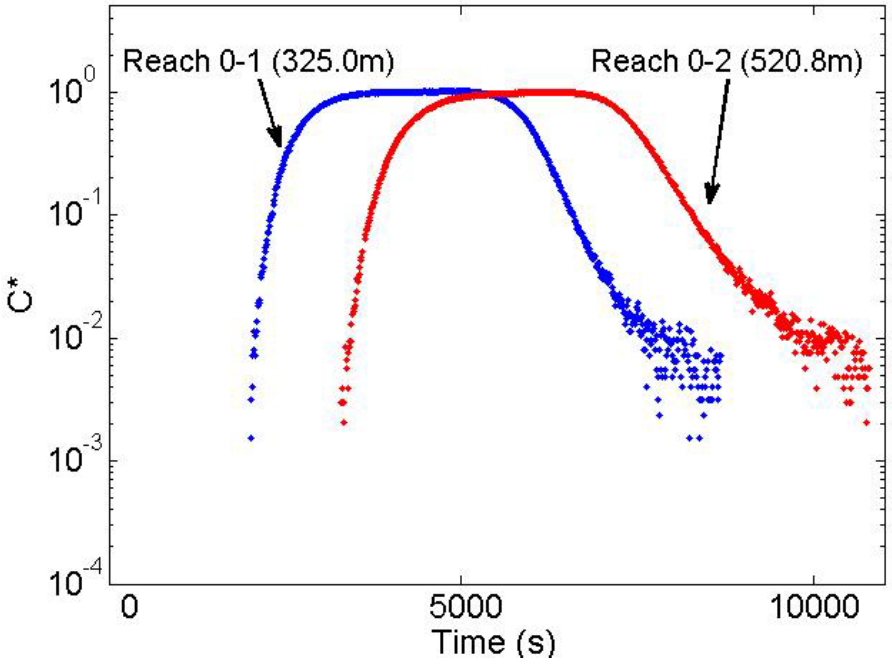
- Reach lengths
  - Reach 0-1 = 325.0 m
  - Reach 0-2 = 520.8 m
- Flow rate
  - 0.19 m^3/s
- Tracer test
  - Rhodamine water tracer (RWT)
    - Continuous (step) injection
- Immerged fluorometers
  - SCUFA (10^{-3})
  - YSI 6920 (10^{-3})



Erpe test (2013)

- Naturally developed vegetation

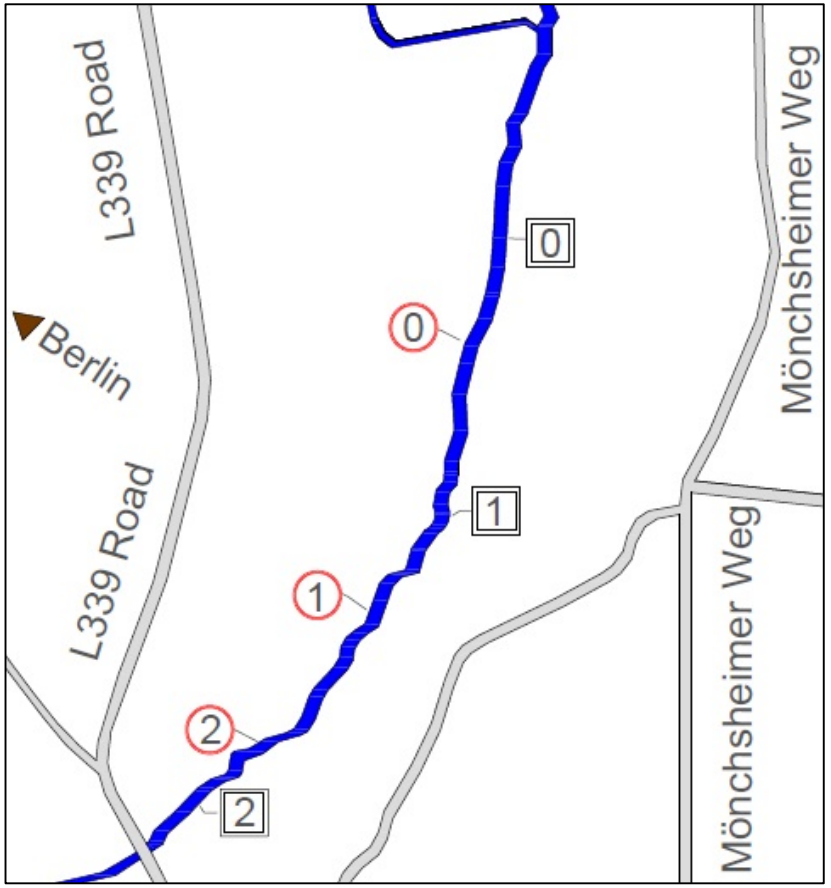
  Thick reparian and submerged



- Recorded breakthrough curves

Erpe test (2014)

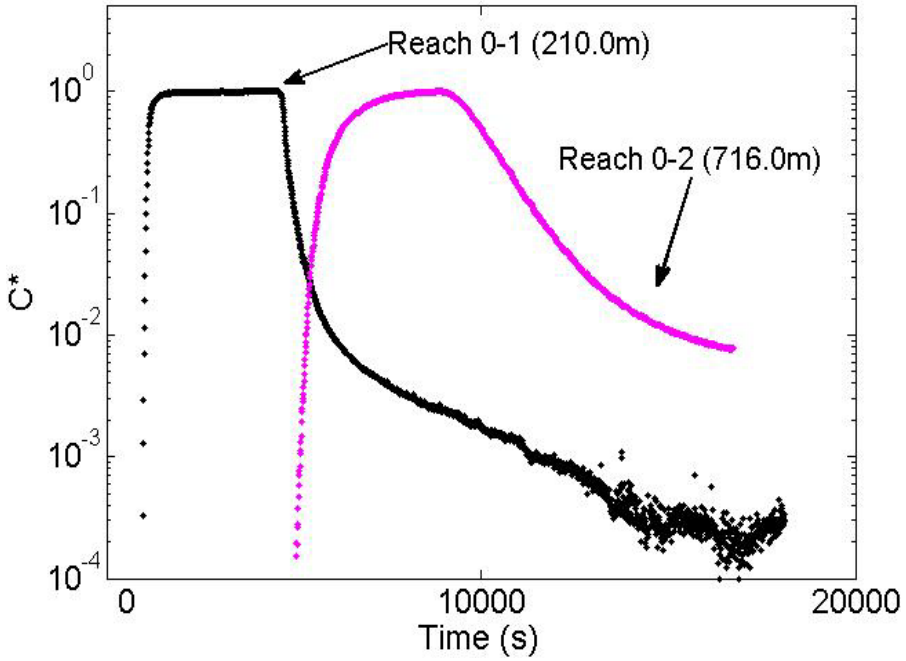
- Reach lengths
  - Reach 0-1 = 210.0 m
  - Reach 0-2 = 716.0 m
- Flow rate
  - 0.08 m^3/s
- Tracer test
  - Rhodamine water tracer (RWT)
    - Continuous (step) injection
- Fluorometers
  - GGUN-FL30 (10^{-4})



Erpe test (2014)

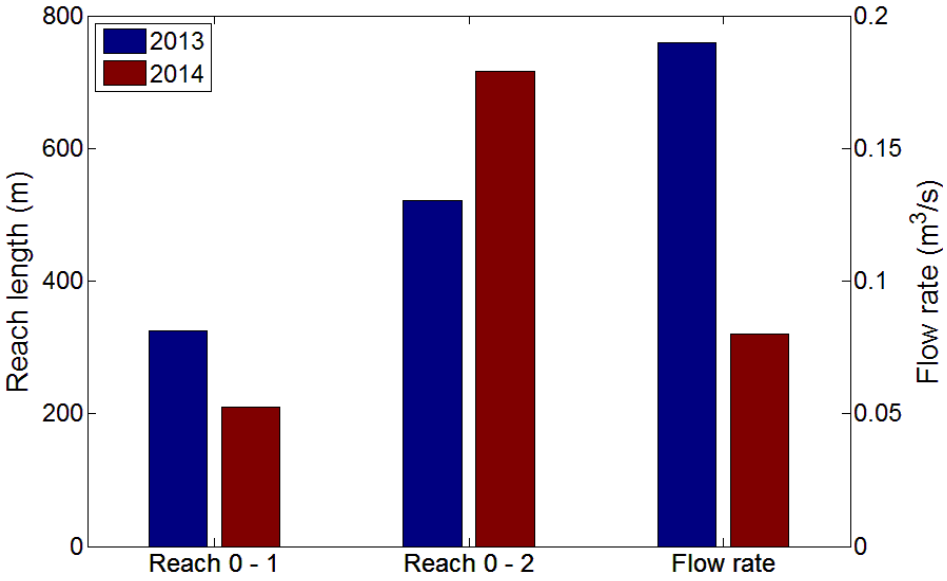
- Vegetation clean condition

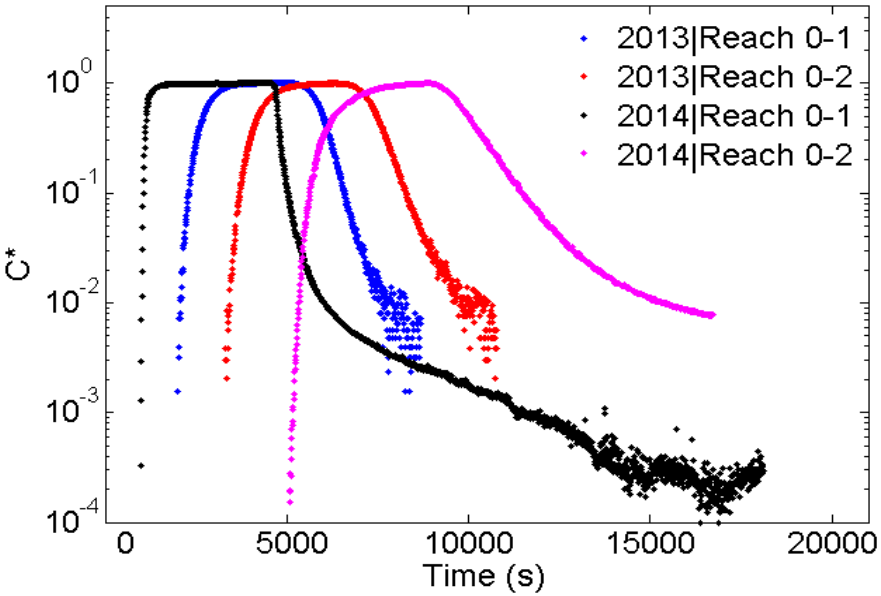
  Removed by authorities



- Recorded breakthrough curves

Erpe tests summary





Different

- Vegetation conditions
- Reach lengths
- Flow rate
- Fluorometers

STIR coding calibration

Input Parameters

A – *Flow channel area*
Q – *Flow rate*
L – *Reach length*

T – *recorded BTC time vector*
Co – *recorded BTC concentration vector*

T_{ups} – *upstream boundary time vector*
C_{ups} – *upstream boundary concentration vector*

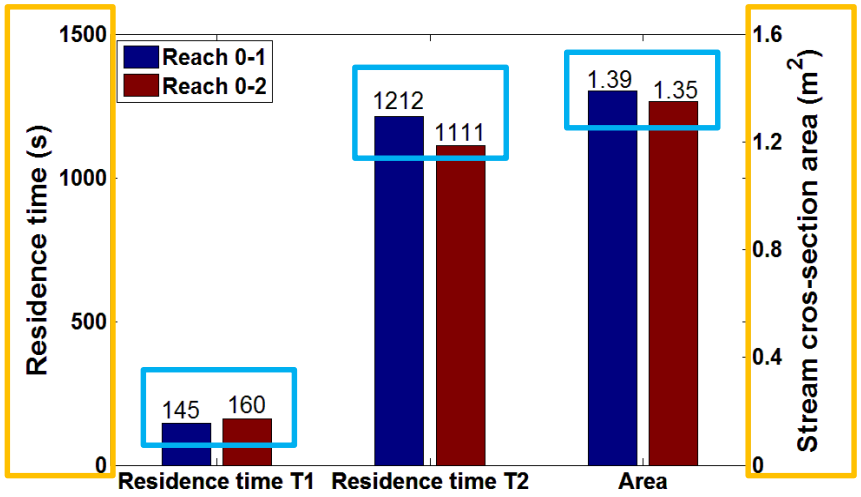
STIR

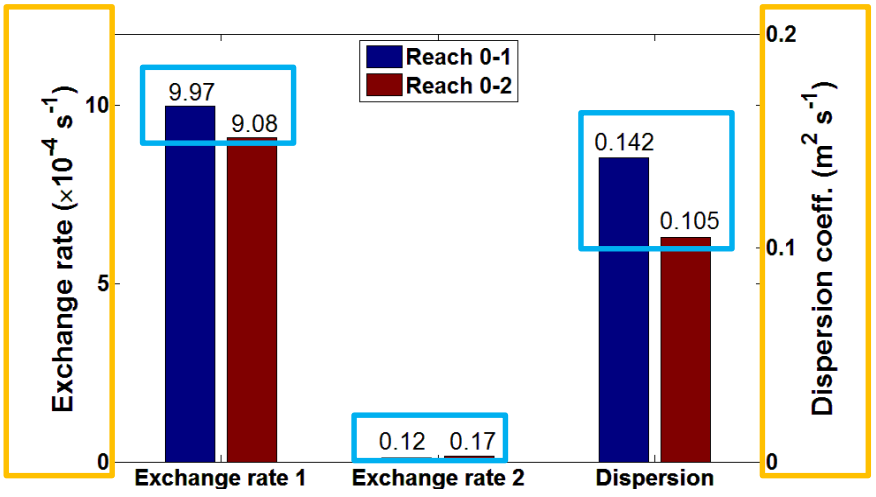
- 2 exponential RTD + Lateral inflow + decay
- 2 storage domains with 2 exponential RTDs
- 2 exponential RTDs
- 6 exponential RTDs
- 2 exponential RTDs + Truncated power-law RTD *(Haggerty & Wondzell)*
- 1 exponential RTDs + Pumping RTD *(Elliott & Brooks)*

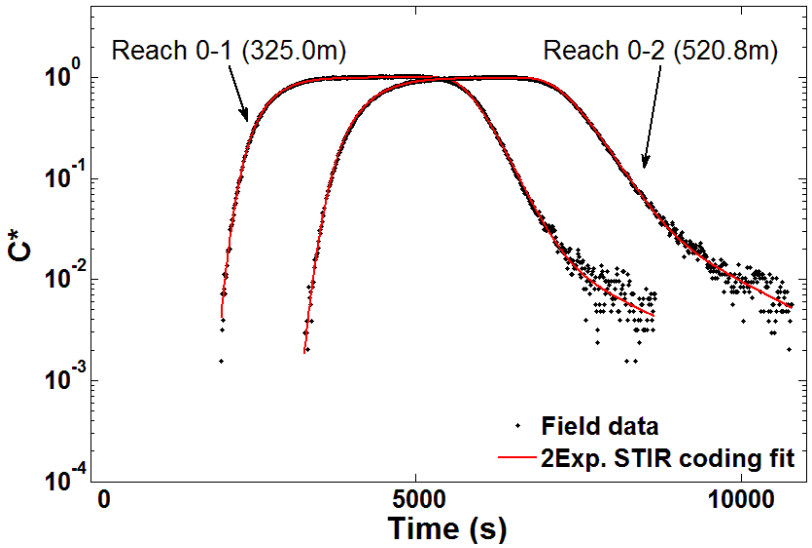
Calibration Parameters

A – *Flow channel area*
D – *Longitudinal dispersion*
T – *Residence timescale*
α – *Exchange rate*

Erpe results (2013)

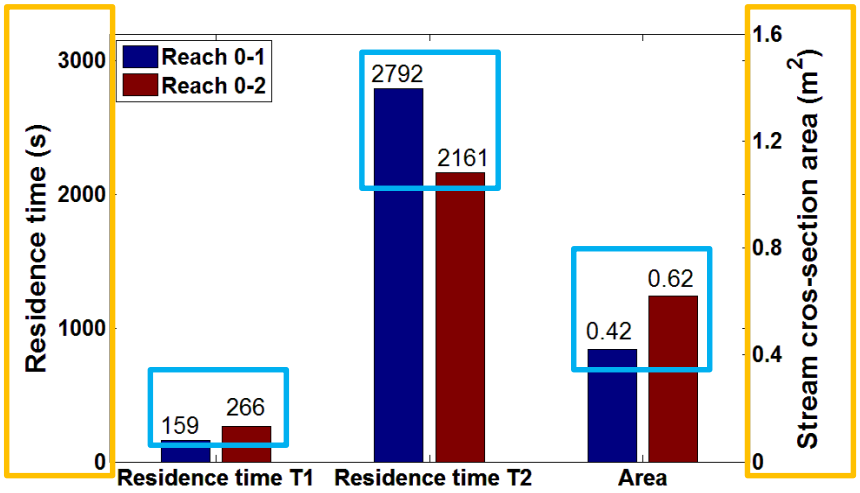


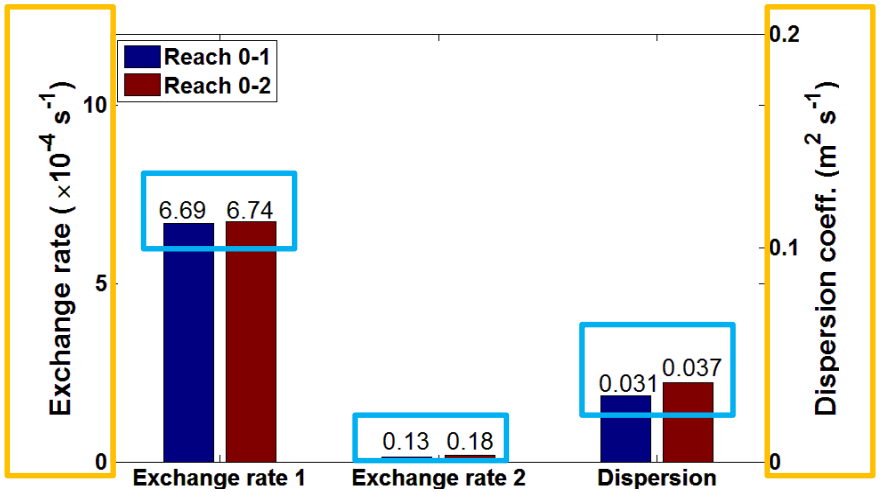


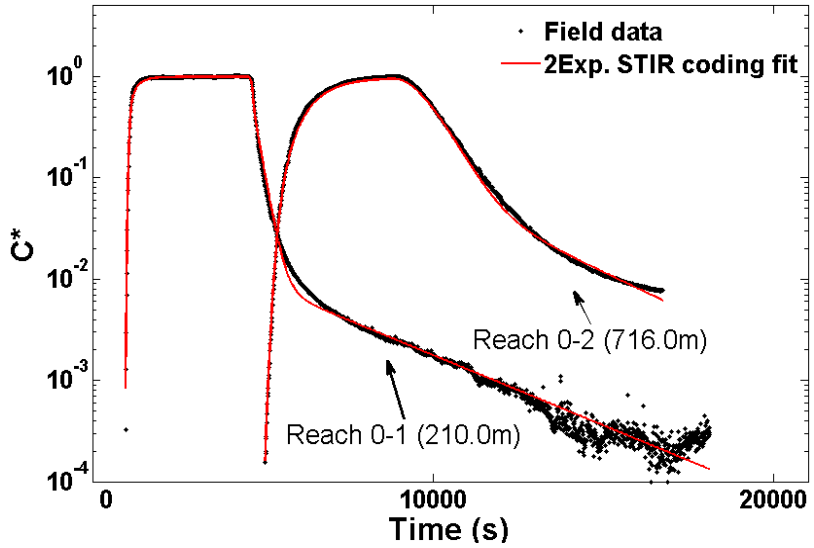


- Residence time T_1 (9 %)
- Residence time T_2 (8 %)
- Cross–section area A (3 %)
- Exchange rate α_1 (9 %)
- Exchange rate α_2 (42 %)
- Dispersion coeff. D (26 %)

Erpe results (2014)

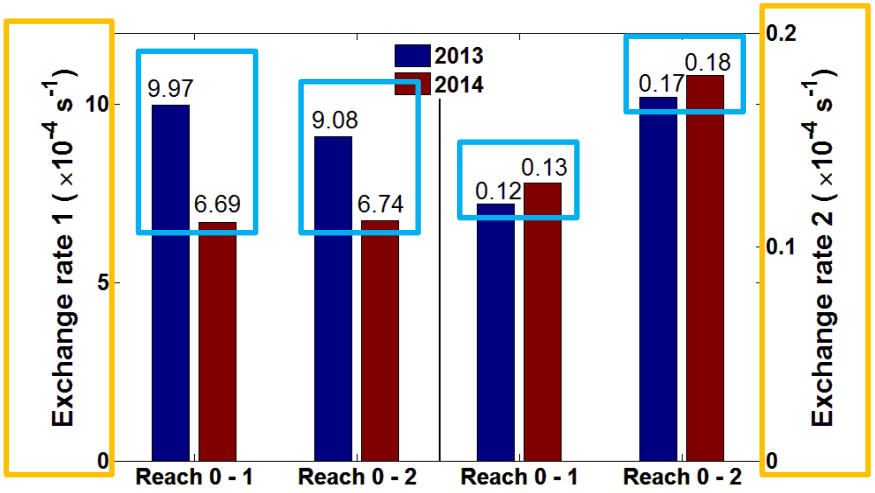


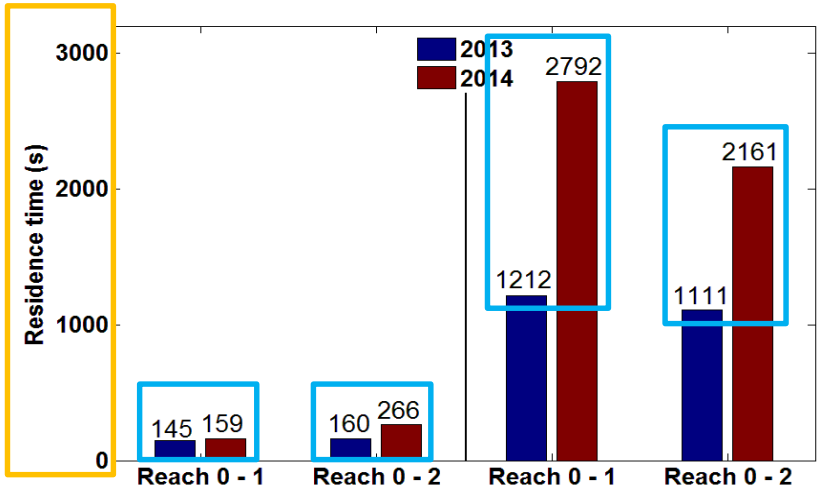


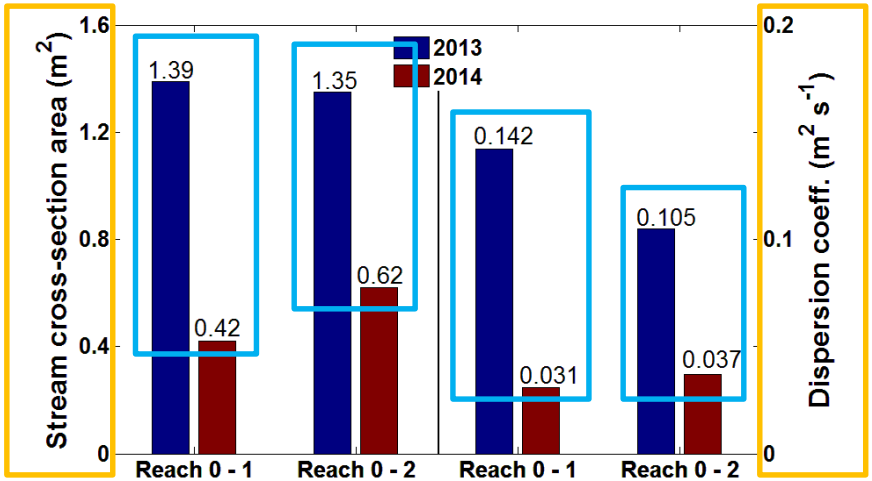


- Residence time T_1 (67 %)
- Residence time T_2 (23 %)
- Cross–section area A (48 %)
- Exchange rate α_1 (1 %)
- Exchange rate α_2 (38 %)
- Dispersion coeff. D (19 %)

Erpe results (2013 vs 2014)







- Exchange rate α_1 (33–26 %)
- Exchange rate α_2 (8–6 %)
- Residence time T_1 (9–66 %)
- Residence time T_2 (130–95 %)
- Cross–section area A (70–54 %)
- Dispersion coeff. D (78–65 %)

Results conclusion

- Increase of flow rate and vegetation improves longitudinal dispersion
- For short reaches, vegetation is enable to balance out flow rate effects
- Dispersion coefficient is more influenced by flow rate rather than reach length
- Resolution of BTC tail strongly affects the hyporheic residence time

Questions