Spatio-temporal variations of water sources and mixing degrees in a floodplain

Guilherme Nogueira[1], Christian Schmidt[2], Daniel Partington[3], Philip Brunner[4], Jan H. Fleckenstein[1,5]

1- Helmholtz Centre for Environmental Research - UFZ, Leipzig, Germany; 2- Helmholtz Centre for Environmental Research - UFZ, Magdeburg, Germany
3- Flinders University, Adelaide, Australia; 4- University of Neuchâtel, Neuchâtel, Switzerland; 5- BAYCEER, University of Bayreuth, Bayreuth, Germany

UFZ HELMHOLTZ Centre for Environmental Research

UNIVERSITÄT BAYREUTH

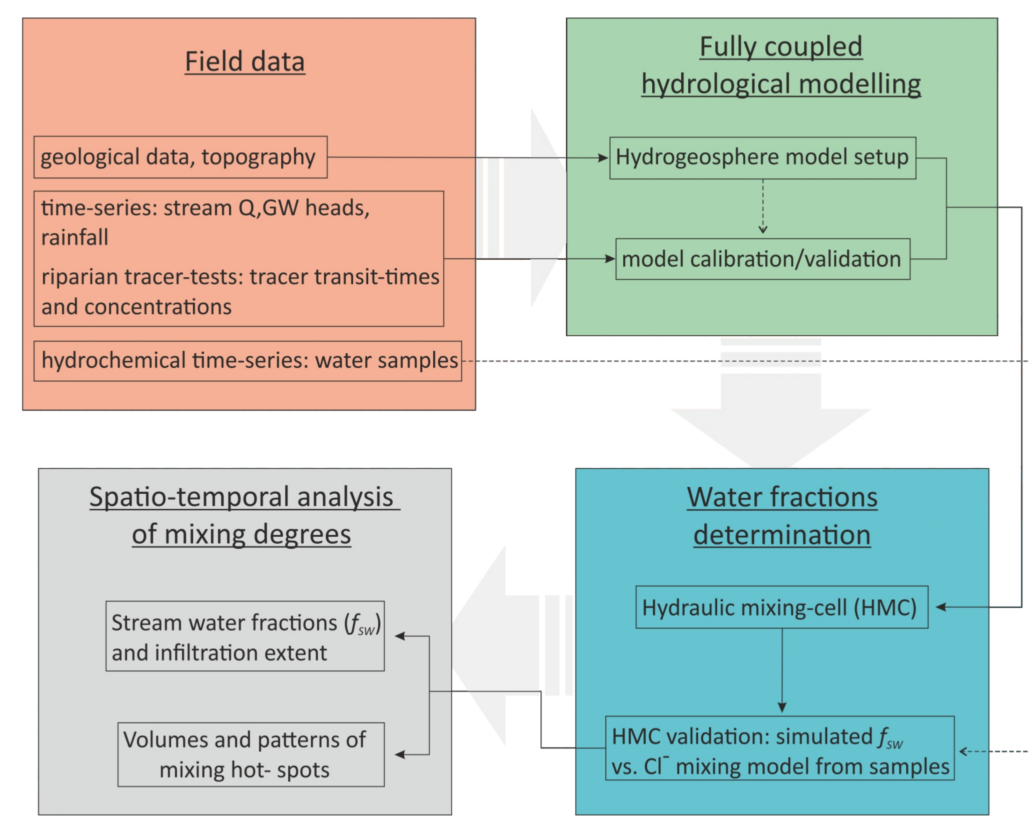
1 Introduction

- Floodplains and riparian zones are characterized by interconnected hydro-biogeochemical processes relevant for the aquatic ecossystem.
- Mixing of different waters in the riparian aquifer can bring reactants in contact and boost (or trigger) mixing-dependent biogeochemical reactions.
- The identification of *mixing hot-spots* (i.e., zones with a more uniform distribution of different water sources) is still difficult.
- The development of *mixing hot-spots* and its relation with flow dynamics can be related to turnover of groundwater-borne solutes in the riparian zone.

2 Methods and Study Area

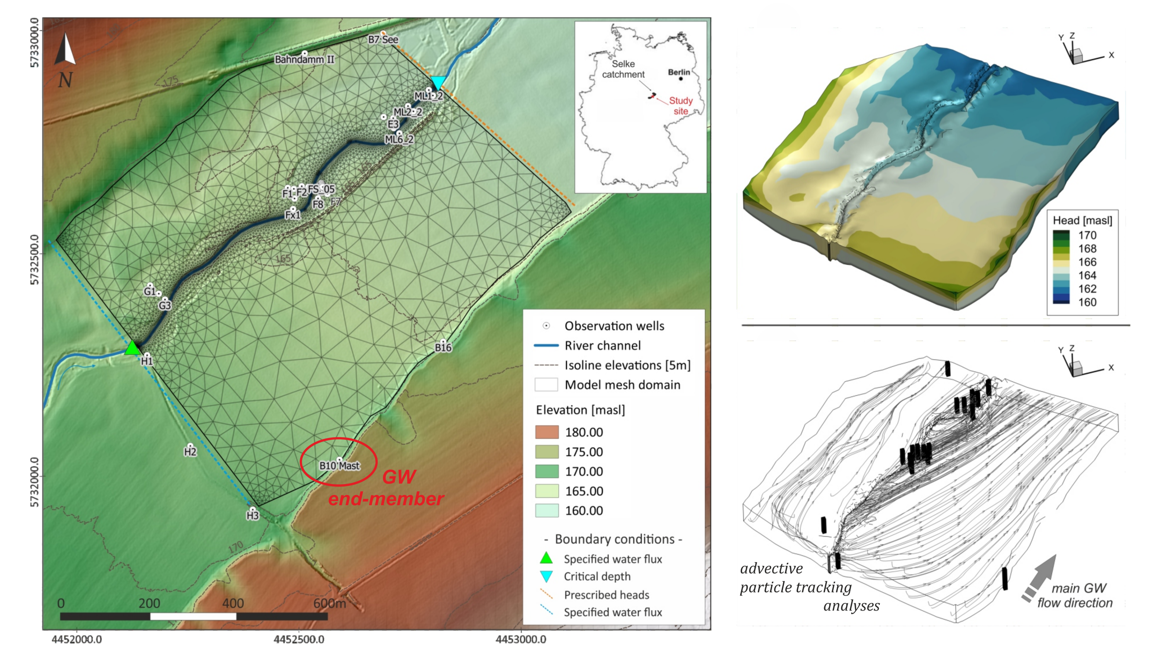
Transient numerical simulations (Hydrogeosphere)

- Previous automated calibration (PEST) *(Nogueira et al., under review)*.
- Validation against stream discharge and GW-heads.



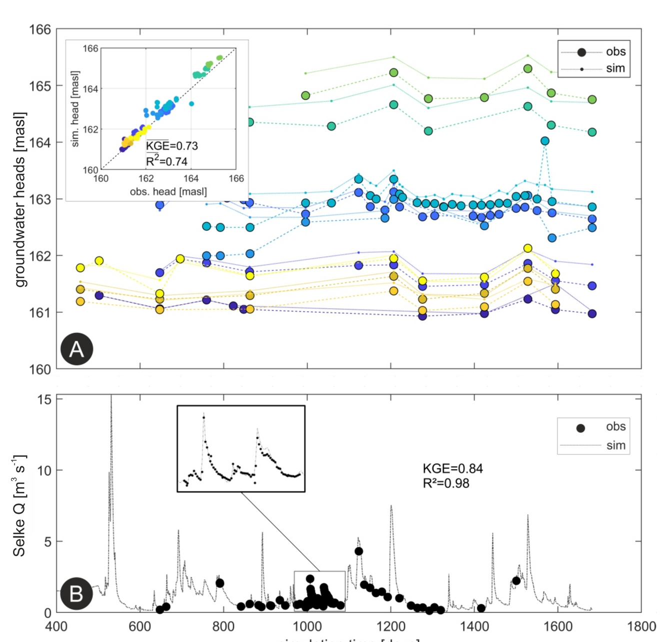
Hydraulic Mixing Cell (HMC) method *(Partington et al., 2011)*

- Water fractions (i.e., stream f_{SW}, groundwater f_{GW}, from soil surface f_{FD}) computed for every cell in each time-step according to water fluxes between model cells.
- Validation of HMC results against river water fractions (F_{RIV}, Cl^- mixing model) on riparian wells. *(Trauht et al., 2018)*

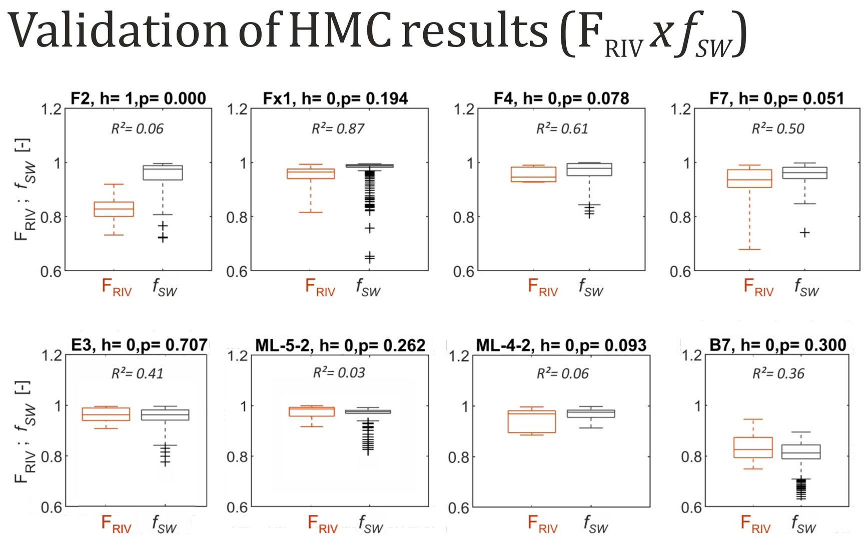


3 Integrating numerical modelling and HMC results

Validation of flow simulations

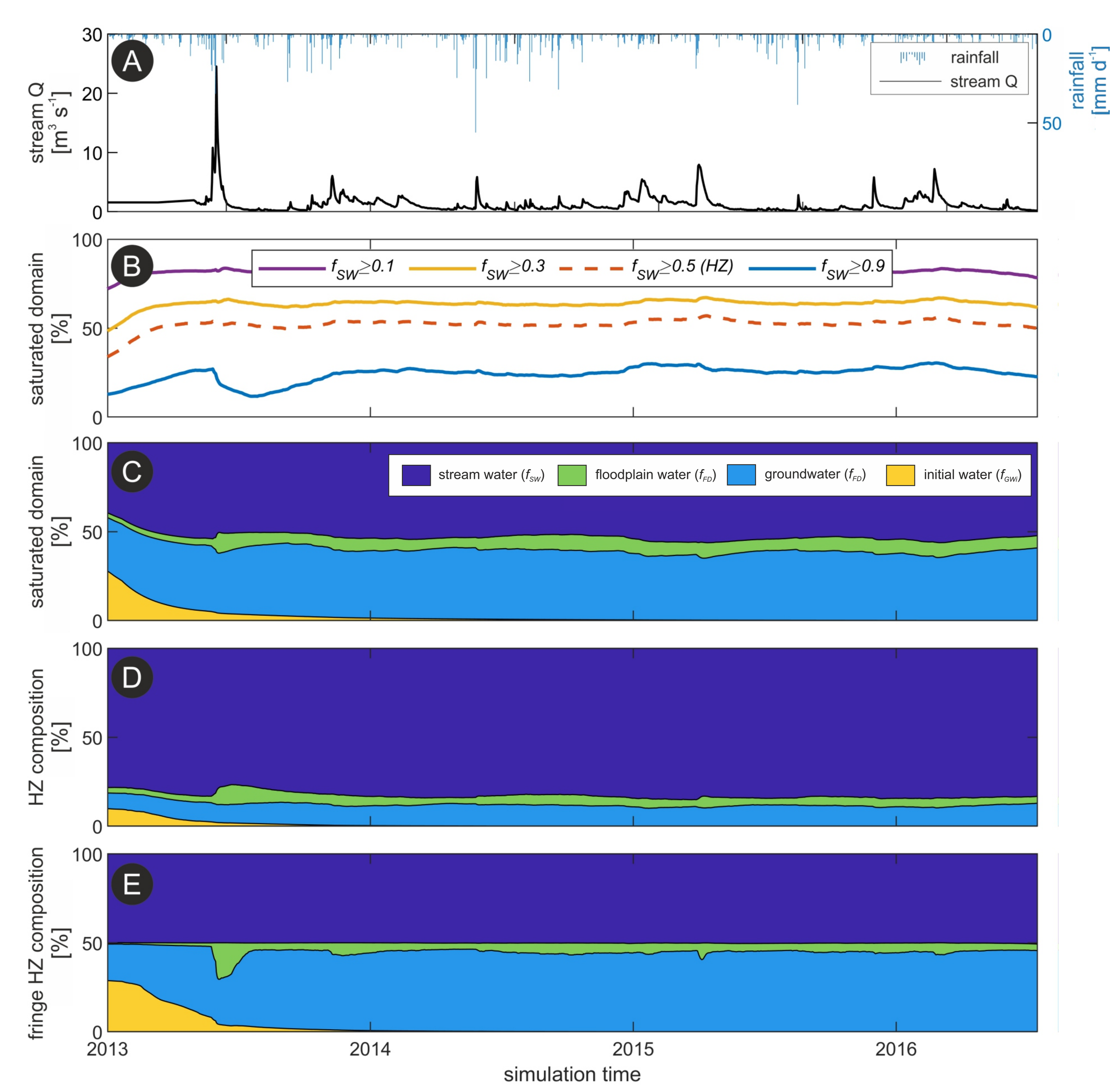


Validation of HMC results (F_{RIV} x f_{SW})

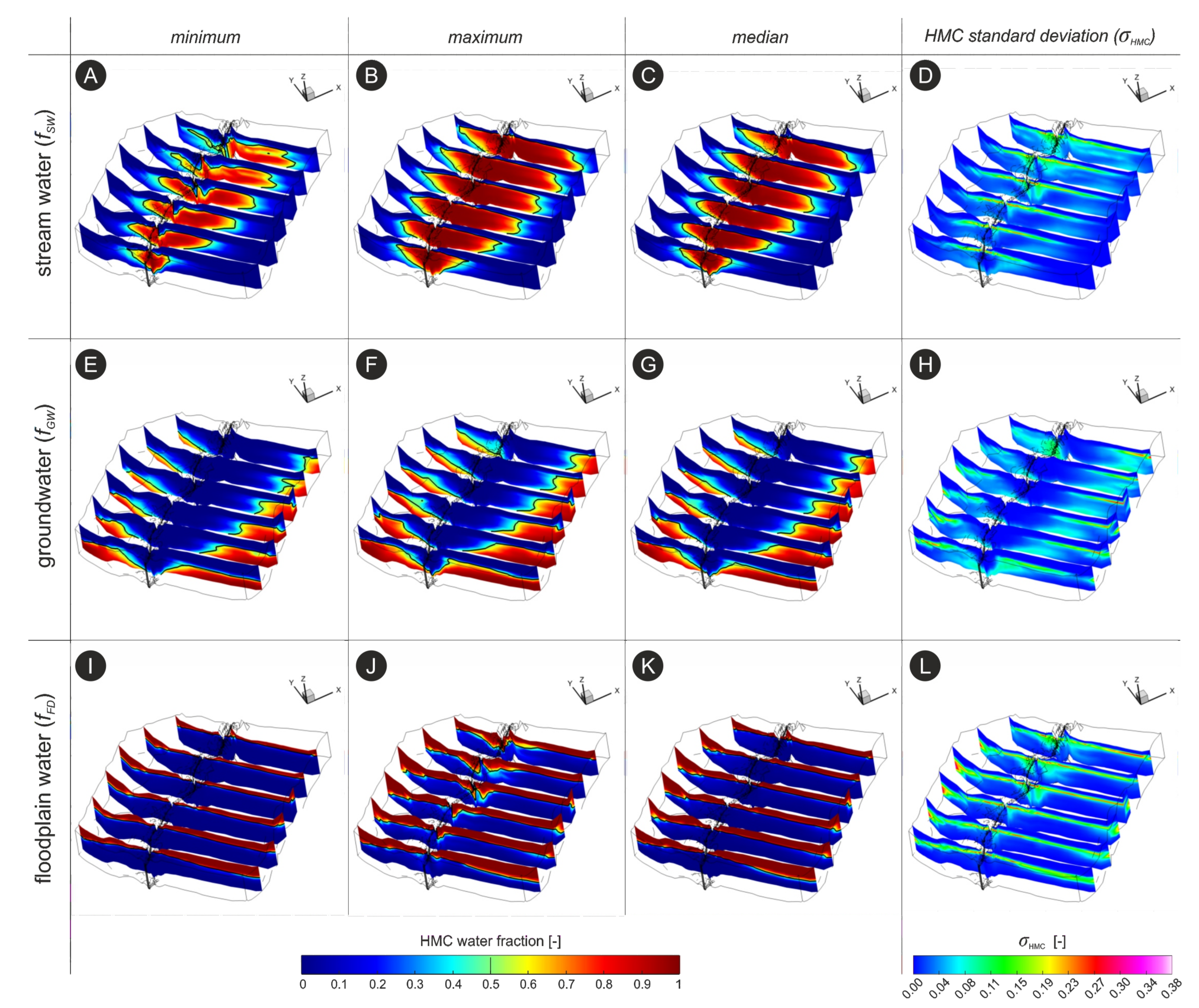


(coeff. determ., R^2); (Wilcoxon-test result, h)

HMC fractions and geochemical hyporheic zone (HZ, $f_{SW} \geq 0.5$)



Nearly constant distribution of HMC fractions in the riparian aquifer over time.
Up to 90% of the total volume of the domain present $f_{SW} \geq 0.1$. Up to 10% present $f_{SW} \geq 0.9$.



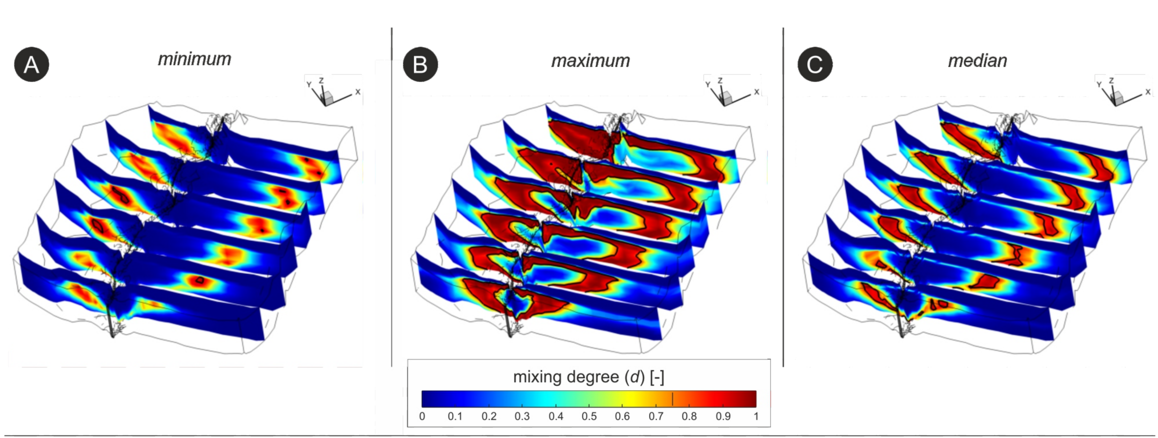
Around 80% of HZ volume comprised by stream water (f_{SW}); a thin *mixing zone*
Geochemical hyporheic zone around 50% of total volume of domain

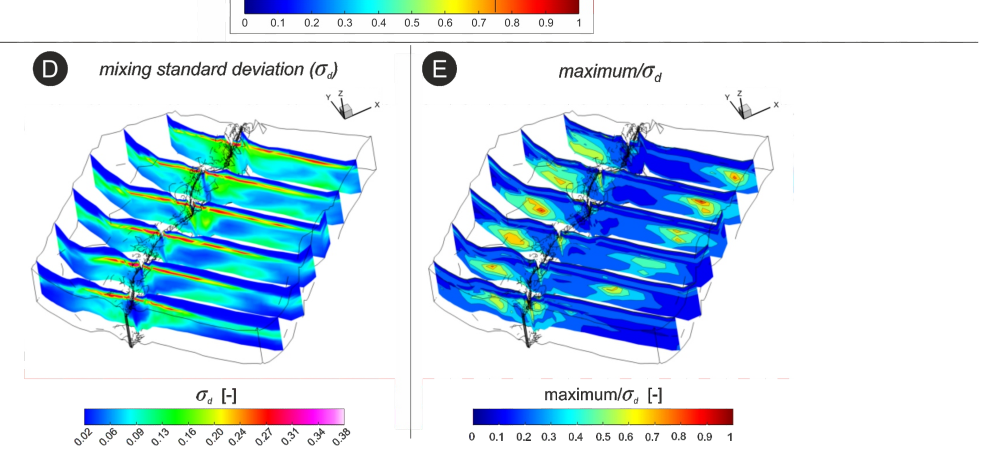
4 Mixing degrees and *mixing hot-spots* (d_h)

Mixing degrees (d)

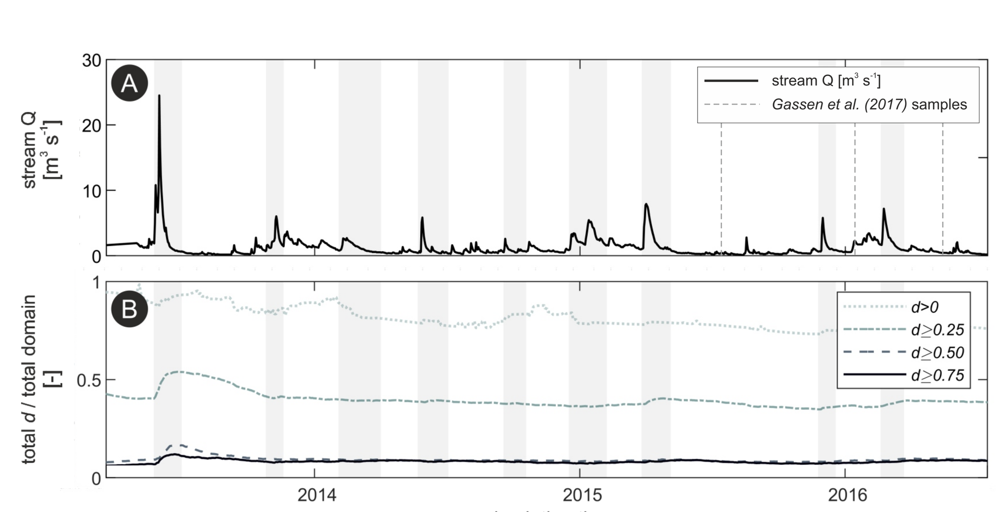
$$d = 1 - \left[\frac{\sqrt{\left(1/2 - f_{SW}\right)^2 + \left(1/2 - \left(f_{GW} + f_{FD}\right)\right)^2}}{\left(\sqrt{2}/2\right)}\right]$$

mixing hot-spots (d_h) = $d > 0.75$



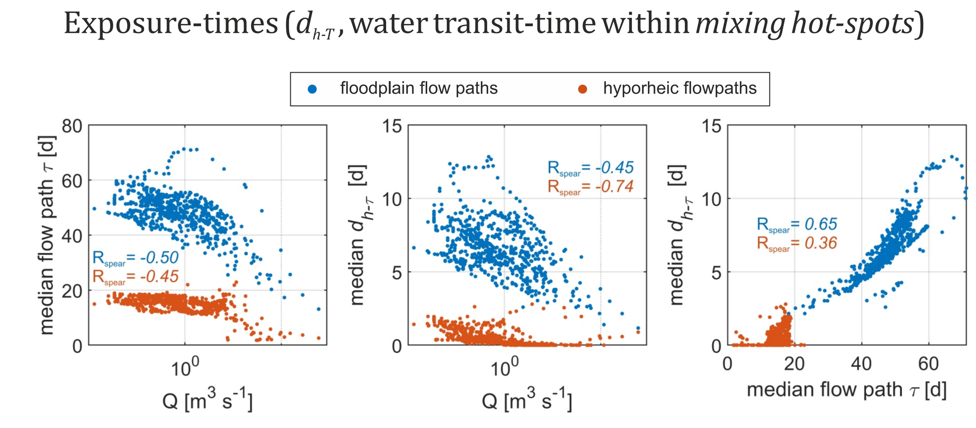


Mixing hot-spots (d_h) comprise on average 10% of the domain.

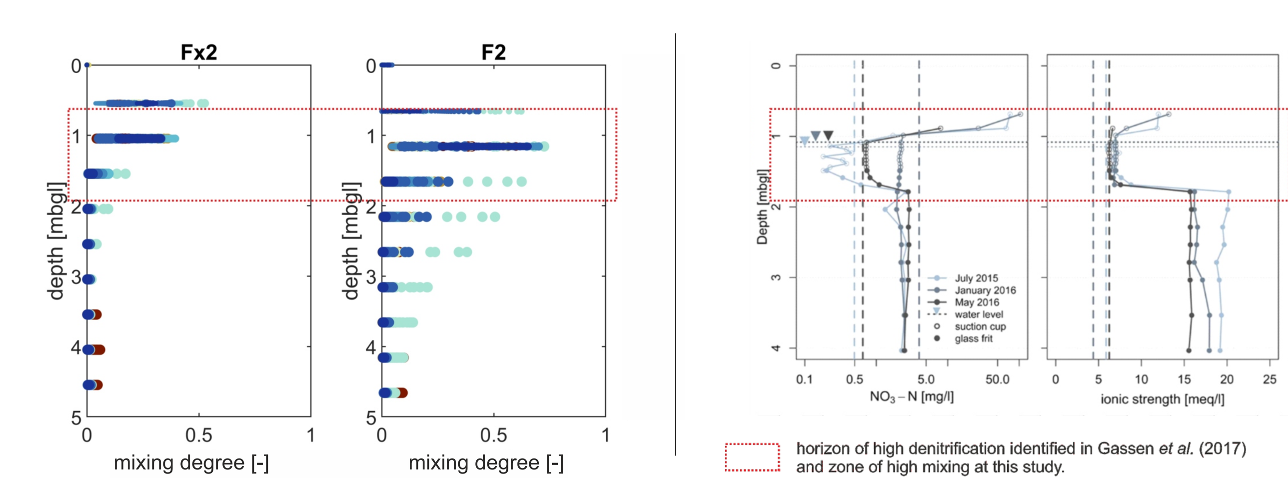


Increasing in d_h in discharge events mainly related to peak prominences (R^2=0.96).

Exposure-times (d_{h-T}, water transit-time within *mixing hot-spots*)



5 Implications and Outlook



High mixing degrees and mixing-dependent denitrification fringe (groundwater NO_3^- + stream DOC) *(Gassen et al., 2017)*

- Widespread occurrence of infiltrating SW nearby the stream, with barely no mixing with other water sources, and a relatively thin SW-GW mixing zone.
- *Mixing hot-spots* comprise 10% of the floodplain on average, but could be nearly 1.5 time higher after discharge events.
- Discharge events mainly increase SW-GW mixing at greater distances from the stream; Near the stream, the mixing decreases with stream discharge due to increasing SW influx and reduced transit-time (i.e., short exposure-time).

Contact: Guilherme Nogueira
Helmholtz Centre for Environmental Research - UFZ,
Permoserstraße 15, 04318 Leipzig, Germany,
guilherme.nogueira@ufz.de

References: **Gassen, N., Griebler, C., Werban, U., Trauth, N., Stumpp, C.**, 2017. *High Resolution Monitoring Above and Below the Groundwater Table Uncovers Small-Scale Hydrochemical Gradients. Environ. Sci. Technol. 51, 13806–13815. https://doi.org/10.1021/acs.est.7b03087*

Partington, D., Brunner, P., Simmons, C.T., Therrien, R., Werner, A.D., Dandy, G.C., Maier, H.R., 2011. *A hydraulic mixing-cell method to quantify the groundwater component of streamflow within spatially distributed fully integrated surface water-groundwater flow models. Environ. Model. Softw. 26, 886–898.* https://doi.org/10.1016/j.envsoft.2011.02.007

Trauth, N., Musolff, A., Knöller, K., Kaden, U.S., Keller, T., Werban, U., Fleckenstein, J.H., *2018*. River water infiltration enhances denitrification efficiency in riparian groundwater. Water Res. 130, 185–199. https://doi.org/10.1016/j.watres.2017.11.058

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MARIE CURIE ACTIONS

ITN Enigma

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