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

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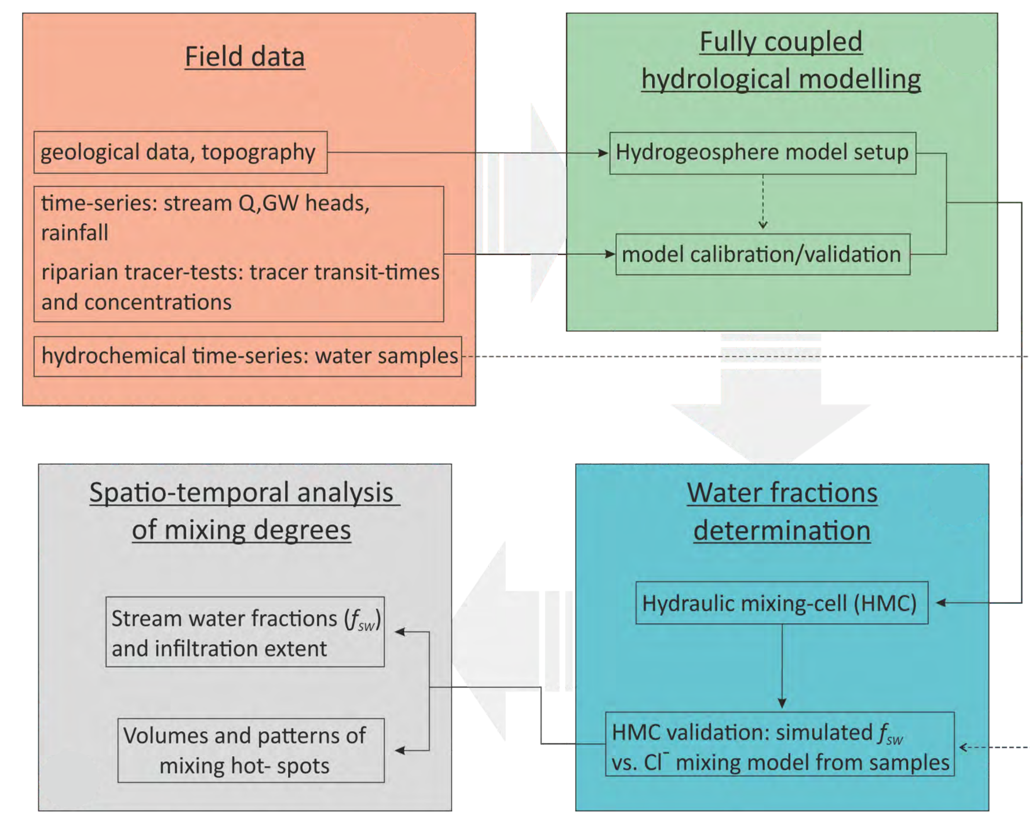
1 Introduction

- 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

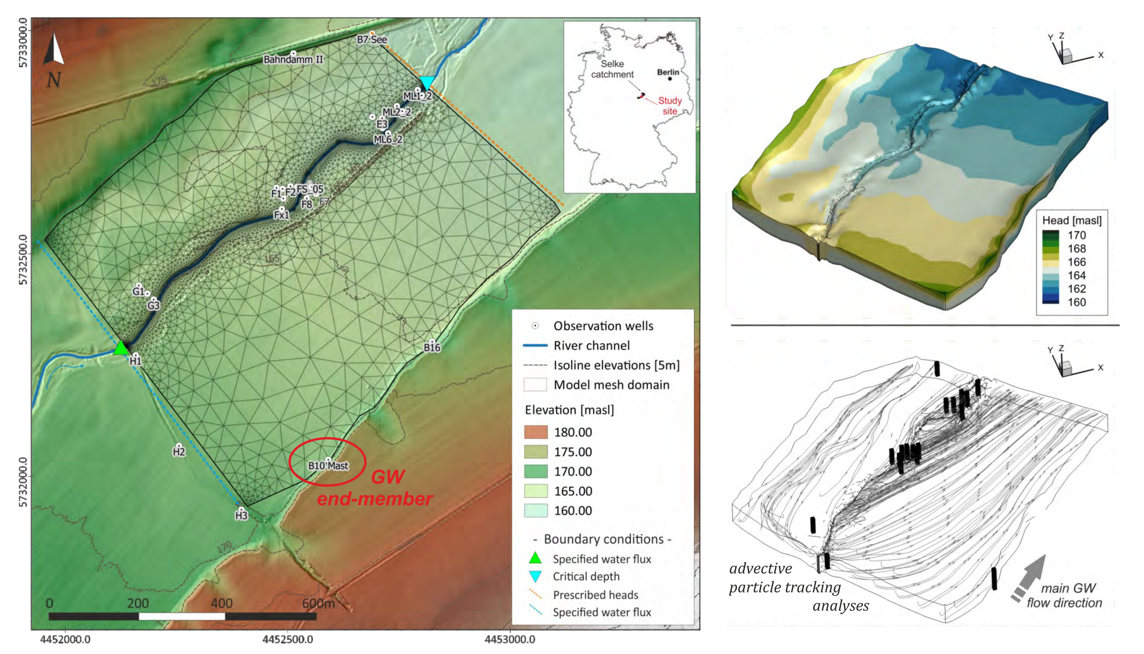
Transient numerical simulations (Hydrogeosphere)

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



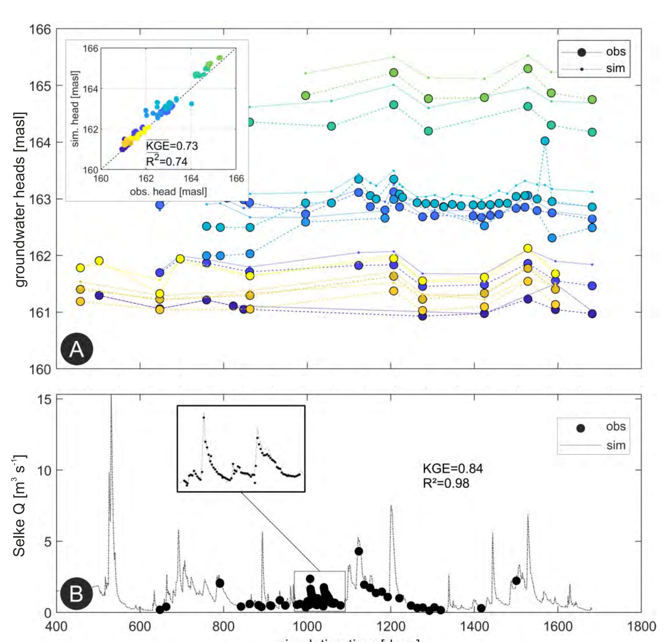
Hydraulic Mixing Cell (HMC) method *(Partington et al., 2011)*

- 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)*

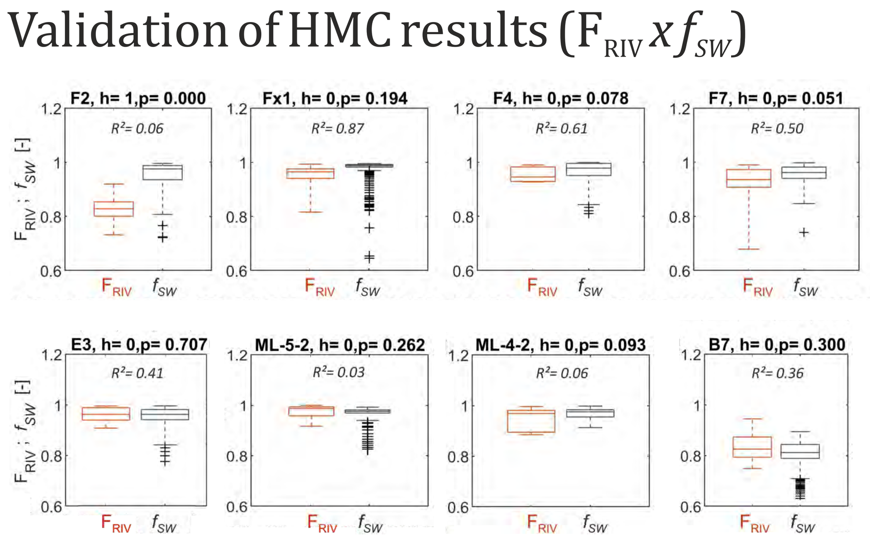


3 Integrating numerical modelling and HMC results

Validation of flow simulations

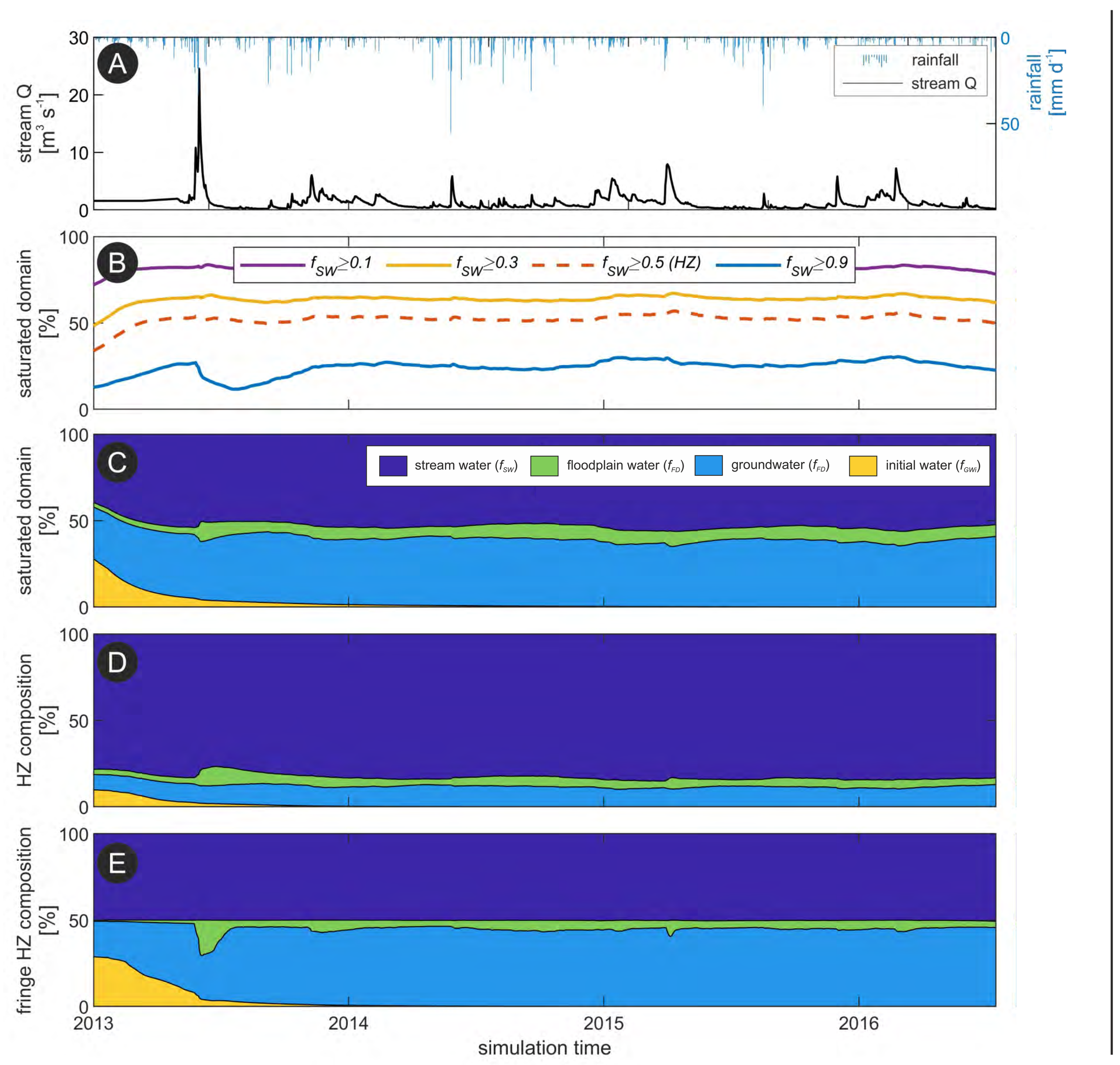


Validation of HMC results (F_{RIV} x f_{SW})

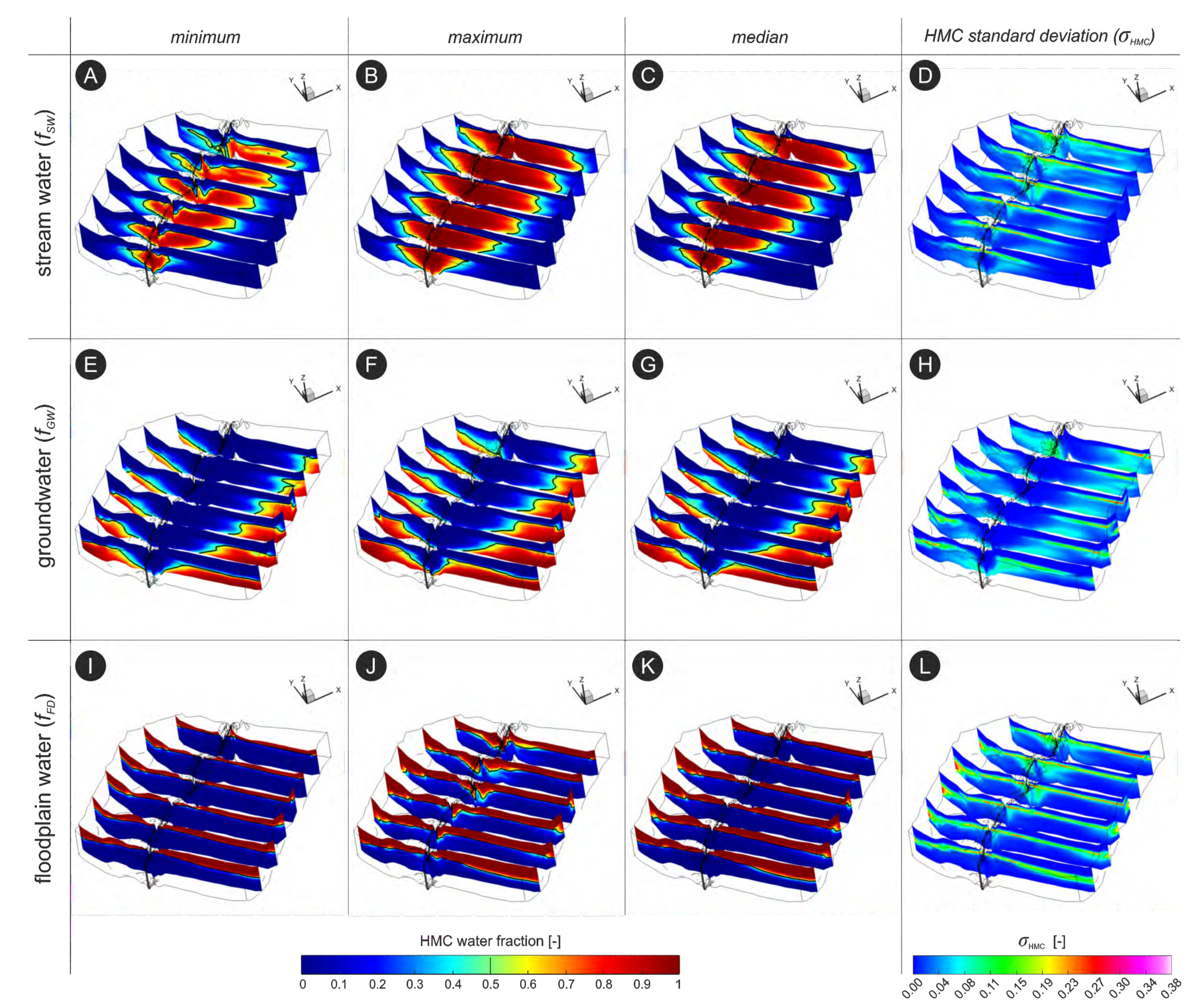


(coeff. determ., R^2); (Wilcoxon-test result, h)

HMC fractions and geochemical hyporheic zone (HZ, $f_{SW}\geq0.5$)



Nearly constant distribution of HMC fractions in the riparian aquifer over time.
Up to 90% of the total volume of the domain present $f_{SW}\geq0.1$. Up to 10% present $f_{SW}\geq0.9$.



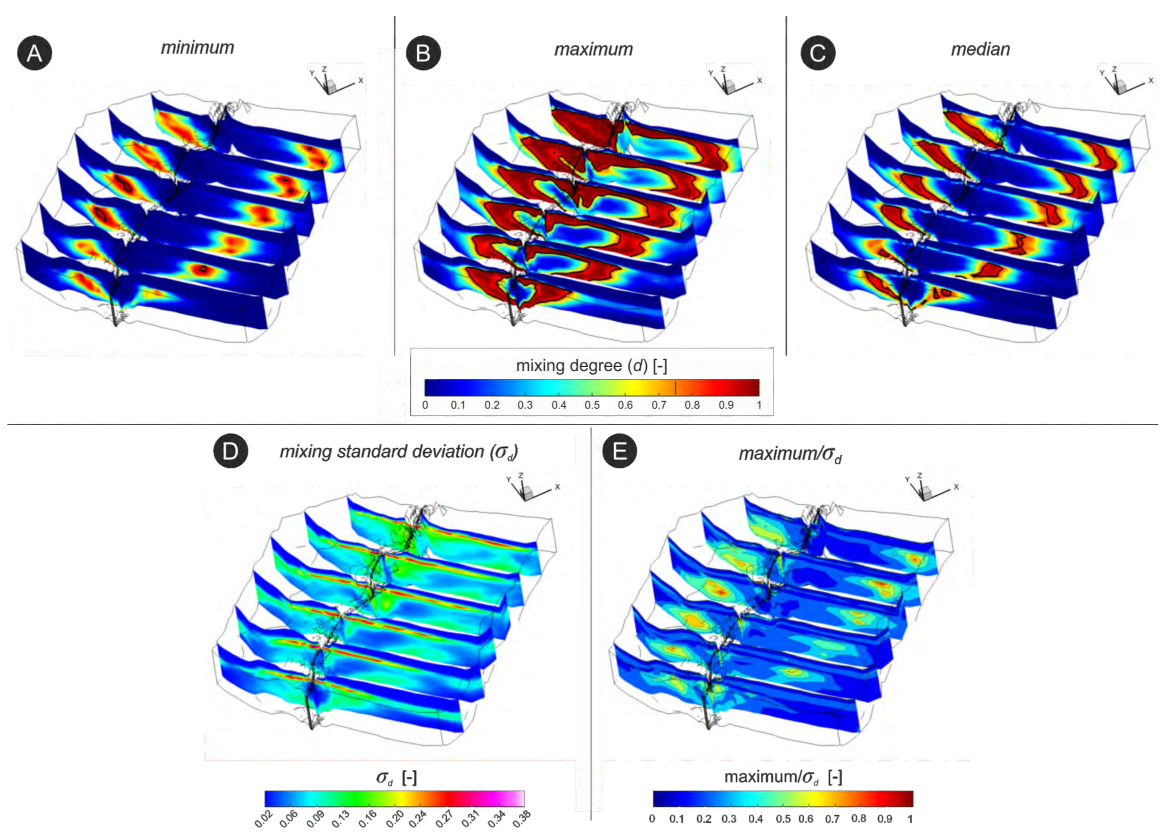
Around 80% of HZ volume comprised by stream water (f_{SW}); a thin *mixing zone*
Geochemical hyporheic zone around 50% of total volume of domain

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

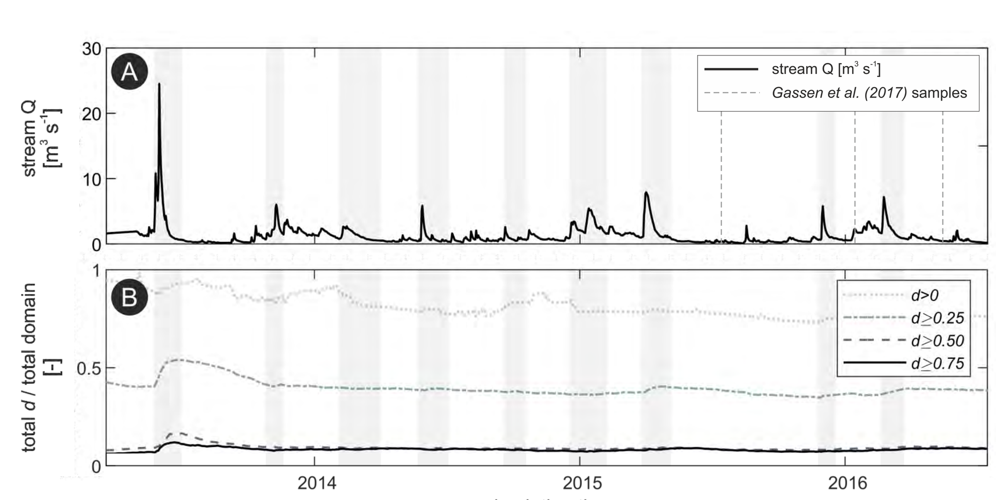
Mixing degrees (d)

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

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

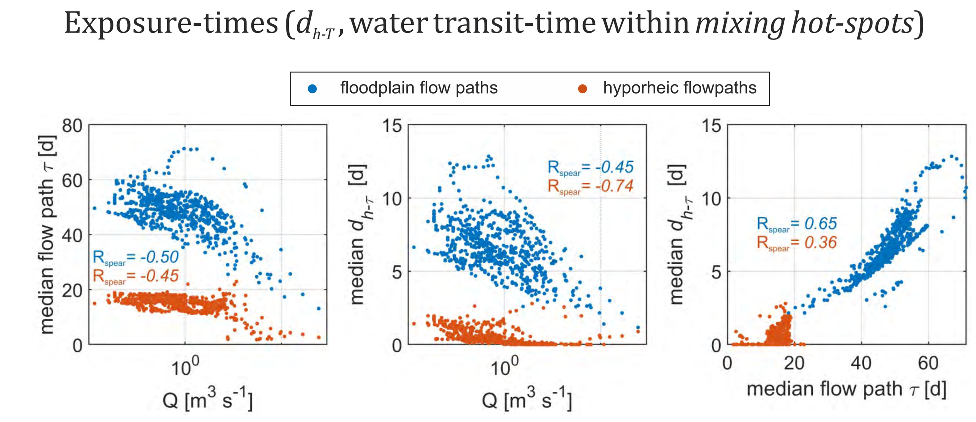


Mixing hot-spots (d_h) comprise on average 10% of the domain.

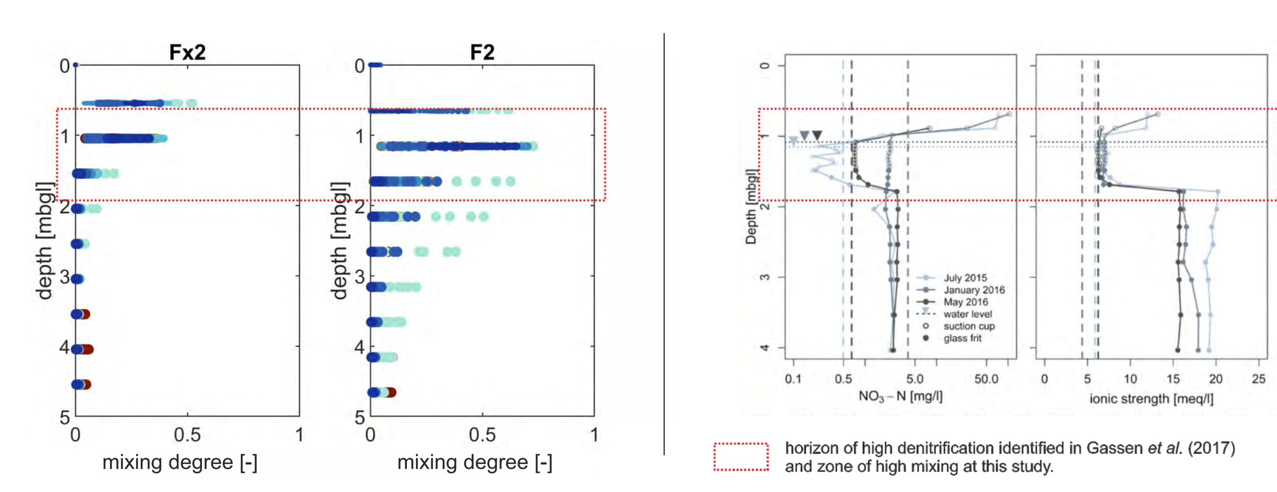


Increasing in d_h in discharge events mainly related to peak prominences (R^2=0.96).

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

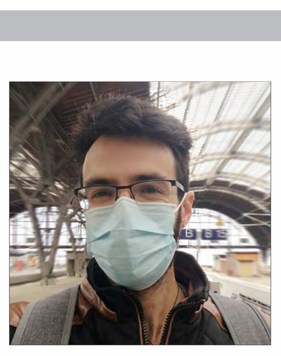


5 Implications and Outlook



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).



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