Investigating the value of regional water isotope data on transit time and SAS modelling

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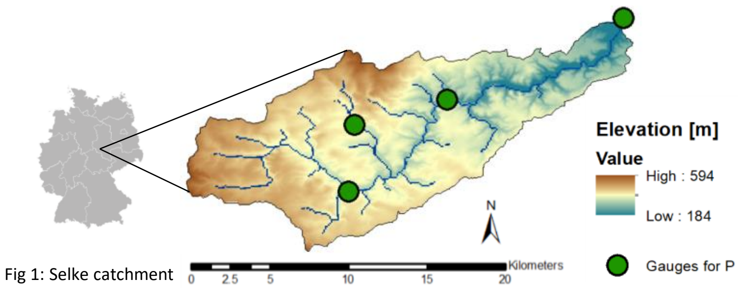

Fig 1: Selke catchment

1. Introduction

Transit time distributions (**TTDs**) of discharge are important to describe **water storage and release** from catchment to streams under dynamic conditions. To investigate TTDs, catchment-scale models based on **StorAge Selection (SAS) functions**[1] are a promising tool. **Tracer data** are often used to validate simulated SAS functions and TTDs. Nonetheless, tracer data are not always available as high-frequency data and at high spatial resolution. Therefore, we tested the impact of different **temporal and spatial interpolation methods** of the stable water isotopes in precipitation on SAS function parameterization.

Objectives:

- Characterize the uncertainties in SAS parameterization and water TTDs with sparse tracer data and different SAS functions
- Apply the **young water fraction** as additional model constraint

2. Data and methods

- Region: upper Selke catchment (184 km²) in central Germany (*Fig. 1*)
- Data: water quantity and stable isotope data from 2012 to 2015 (*Fig. 2*)
- Temporal interpolation: step vs. sinusoidal function
- Spatial interpolation: raw vs. kriging $\delta^{18}O_P$ with additional points[2]

- Input: daily P, Q and ET from hydrological model[3] and measured monthly $\delta^{18}O_P$ and $\delta^{18}O_Q$[2]
- Model: *tranSAS v1.0*[4] to calibrate SAS functions (i.e., power law time-invariant, power law time-variant and beta law) against measured $\delta^{18}O_Q$ and young water fraction (F_{yw}). Behavioral solutions represent 5% with the highest Kling-Gupta efficiency. Uncertainty quantification with GLUE approach
- Output: behavioral SAS parameters, simulated $\delta^{18}O_Q$, TTDs and F_{yw}

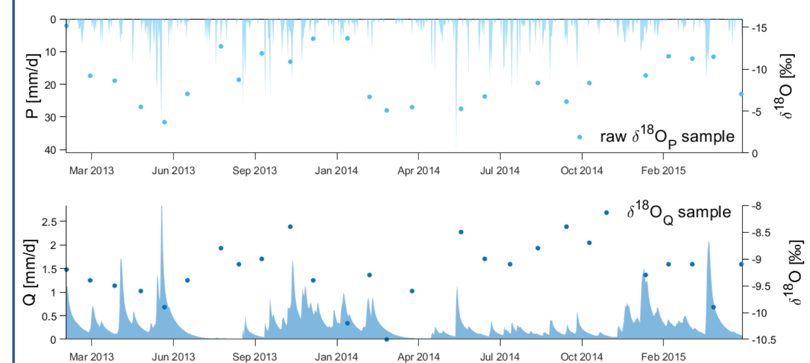

Fig 2: Precipitation (P), discharge (Q) and stable water isotopes ($\delta^{18}O_P$) time series

3. Results and Discussions

SAS parameterization against measured $\delta^{18}O_Q$

- Considerable uncertainties in SAS parameterization: preference for release of different water ages depends on interpolation method for input tracer data and choice of SAS function (*Fig. 3*)

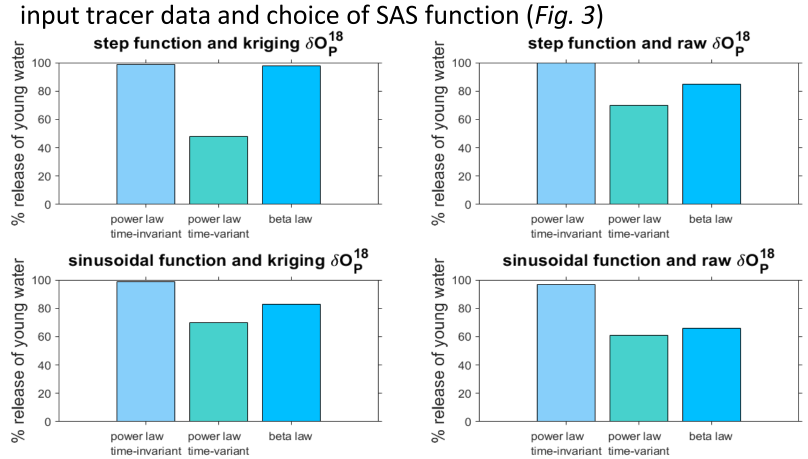

Fig 3: Percentage of behavioral solution with release of young water for each configuration

Water transit time and uncertainty (*Fig. 4*)

- Shorter median transit time (TT_{50}) with kriging $\delta^{18}O_P$ (mean TT_{50}=145 d) than raw $\delta^{18}O_P$ (mean TT_{50}=229 d)
- Larger TT_{50} with sine interpolation (mean TT_{50}=232 d) than step function (mean TT_{50}=142 d)
- Greater uncertainty (U) (i.e., bandwidth between 5th and 95th percentile of behavioral TT_{50}) during base-flow conditions (mean U = 315 d)

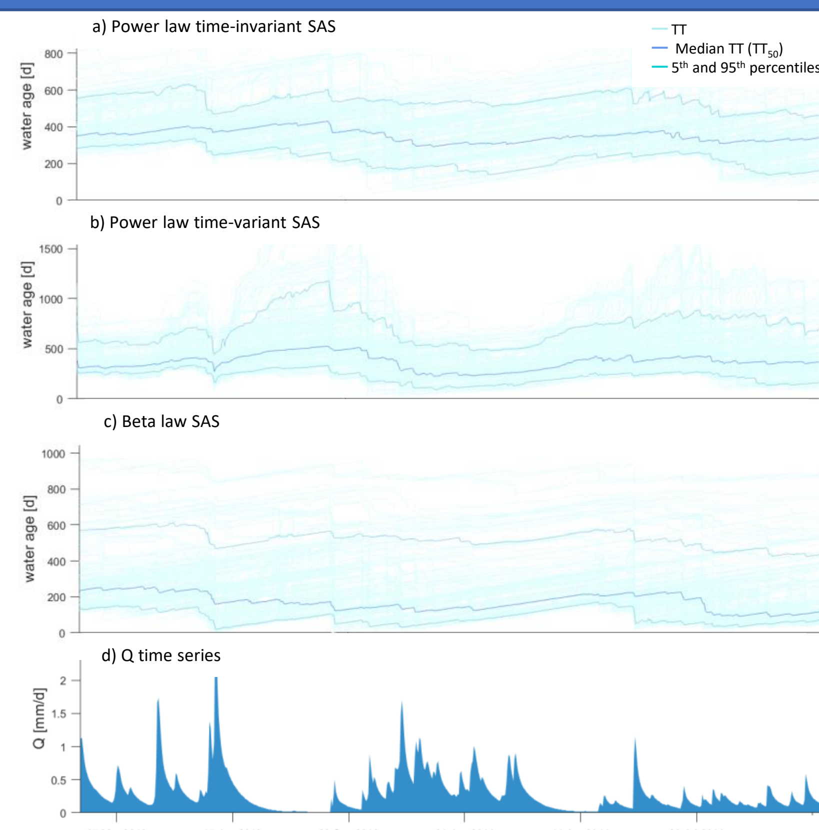

Fig 4: Water age in behavioral solutions for different SAS functions with step function interpolation and raw $\delta^{18}O_P$ (a-c), and Q time series (d)

4. Outlook

- F_{yw} (water younger than 2-3 months[5]) used as additional constraint
- Selection of a subset of behavioral solutions for which the simulated flow-weighted F_{yw} is matching F_{yw} from measured $\delta^{18}O_P$: F_{yw}=0.21±0.07 (raw $\delta^{18}O_P$) and F_{yw}=0.25±0.08 (kriging $\delta^{18}O_P$)

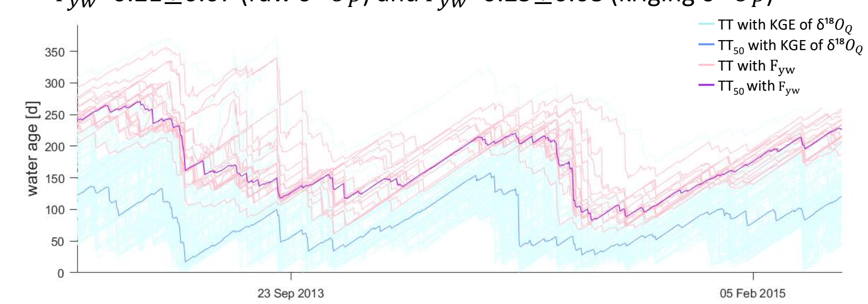

Fig 5: Water age of beta law with step function interpolation and kriging $\delta^{18}O_P$.
Blue palette indicates behavioral solutions with measured $\delta^{18}O_Q$ and pink palette with $\delta^{18}O_Q$ + F_{yw}

5. Conclusions

- **Sparse tracer data** can provide useful information on a **catchment's preference for release water of different ages** and **TT ranges**
- We recommend to **explore the uncertainties** in water transit times resulting from **different SAS functions and interpolation methods** of sparse tracer data
- First results show that the **young water fraction** is a valuable metric in **reducing these uncertainties**

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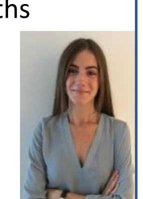

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