R1: “This paper has promise for benefitting the hydrologic community in regards to understanding parameterization of transport metrics via modeling, however, I recommend the authors make some substantial revisions to broaden the audience and better clarify the significance of their results. The following are suggestions/ comments I have that I believe would improve this paper and its impact.”
Authors: We thank the reviewer (R1) for the positive view on our work and for the suggested improvements. We will implement the suggestions in a revised version. In particular, we will improve terminology and structure of the manuscript to broaden the audience and enhance readability.

R1: “The effort put into answering and addressing questions 2 and 3 are not to the same rigor as question 1. Methods, results, and discussion for question 1 is clear, but not for questions 2 and 3.”
Authors: In the revised version of the manuscript we will address these concerns by pointing out the link between methods/results and the respective research questions more clearly. We also may reformulate the research questions to make this clearer.

R1: “The paper is jargon heavy and not readable to a wide audience.”
Authors: We will carefully revise the manuscript to minimize jargon and improve readability.

R1: “Certain vocabulary is not defined or explained well, such as global identifiability vs dynamic identifiability.”
Authors: We will accurately define global identifiability analysis and dynamic identifiability analysis in the revised method section.

R1: “Additionally, many sentences and paragraphs are not fluent and have poor sentence structure, especially throughout the introduction.”
Authors: We will do a careful language editing before resubmission.

R1: “The introduction addresses certain open questions / problems but then lists specific questions being answered. It’s then confusing as to what questions will and will not be addressed in this paper. I think it would benefit readers to remove the earlier questions mentioned and stick with the ones at the end of the introduction.”
Authors: In the introduction we indicated certain open questions / problems to indicate what are the possible causes that could have induced non-identifiability of TSM parameters in previous studies. However, based on the comments we understand that they were unclearly presented in relation to the investigated research question. We will re-write or remove these open questions / problems to better develop the introduction toward the investigated research questions.

R1: “For the methods section, there is no explanation of how question 2 was answered.”
Authors: We will modify the manuscript to clearly present how the dynamic identifiability analysis was used to address research question 2.

R1: “What specific sections of the BTC did you investigate and how did you break the BTC up into different sections?”

Authors: In the manuscript we refer to three different sections of the BTC: (i) “rising limb” that relates to the sections of the BTC preceding the peak, (ii) the “peak” indicates the maximum recorded concentration of the BTC, and (iii) “tail” that indicates the sections of the BTC following the peak. We will describe how we separated the BTC in the different sections in the revised method section.

R1: “Also, why are the tracer experiments all done during the same season? I acknowledge that the discharge is still varied, but are there other hydrologic processes that change throughout the year not captured by winter tracer studies?”
Authors: This is true, different hydrologic conditions can be characterized by different hydrologic processes at the study site (see Bonanno et al., 2021). However, the focus of this study is on the identifiability of TSM parameters to derive solute transport metrics. The question of how changing processes with changing hydrological conditions impact transient storage is, however, highly interesting and open research. Building on the current modelling work, our follow-up research will address this. However, we believe that this goes beyond a realistic scope of the current manuscript.

R1: “I believe a simple reactive transport study using the different parameter estimates would enhance this study and better highlight the impact and importance of the uncertainty in parameter estimation.”
Authors: This would absolutely be a very interesting complementary study. We believe that coupling reactive tracer experiments with the proposed methodology will offer valuable insights on the physical meaning of transient storage parameters and can be a valuable follow-up of the current study. There is a lot of future research needed to address the complexity of in-stream transport. However, we believe that this would need to be a standalone study.

R1: “There is little explanation on whether or not their results make sense in the context of physical hydrologic processes and past studies"
Authors: We will clarify how and why our results make sense in the hydrologic context of the study site. The study site is equipped with a dense network of groundwater monitoring wells (Bonanno et al., 2021). The measured groundwater levels in the well network showed that the stream channel is almost entirely in gaining conditions during the investigated tracer injections. These data indicate a lack (or very limited) hyporheic exchange at the study site, which is in line with the obtained TSM transport metrics that show short residence time in the transient storage zone (from ~150 s for E1 to ~33 s for E3, line 354). We will refer to the groundwater monitoring network in the method section and we will implement in the discussion section how our TSM results are in agreement in the context of physical hydrologic processes occurring at the study site. We will also briefly compare our results with previous studies at other sites. Specifically, a decrease of both A_TS and tracer residence time in the storage zone (Tsto) with increasing discharge conditions was argued to indicate an increase of groundwater gradients toward the stream channel with a consequent decrease of hyporheic zone (Fabian et al., 2011; Morrice et al., 1997). However, groundwater measurements at the study site exclude the presence of significant hyporheic exchange during the three simulated tracer

experiments. In our study, the observed link between TSM results with discharge rather suggests that with increasing discharge conditions the wet stream area and the water depth increased more than the wetted perimeter. This in turn let the wet stream areas to inundate dead-zones and streambed heterogeneities causing a decrease of in-stream transient storage with increasing discharge conditions (Gooseff et a., 2008; Zarnetske et al., 2007).

R1: "Does it make sense that a variable velocity that is not determined a priori make sense?"
Author: It is important to know what are the consequences and the challenges related to the interpretation of modelling result when one or more parameters are not calibrated and evaluated a-priori. This is especially true for TSM where "parameters may be interactive and correlated, meaning that parameters cannot be changed independently of each other" (cfr. Knapp & Kelleher, 2020). This is because a separate estimation of advection parameters (velocity and area) can lead to changes in the evaluation of the transient storage parameters "exactly because of the observed parameter interactions. Consequently, transport parameters may be mis-estimated, if a two-step approach is applied (Lemke et al., 2013)." (cited from Knapp & Kelleher, 2020). Constraining the values of area in random sampling approach for TSM proved to have a role on the identifiability of Alpha and A_TS (Kelleher et al., 2013; Ward et al., 2017), however, no study so far evaluated the role of velocity on the identifiability of TSM parameter. Thus, we tested if calibrating velocity together with the other TSM parameters may have avoided any possible (and previously unknown) parameter interaction leading to a more robust assessment of Alpha and A_TS. We will clarify the research gap that motivated our modelling choice of considering velocity as a calibration parameter in the revised introduction.

R1: "Further, the discussion is sometimes a repeat of results rather than a discussion of the implications of the results. Why do the results matter? How does that align with our current understanding?"
Authors: We will revise the discussion to avoid repetition of the results. By doing so, we believe that we will emphasize the sections where we compare our results with previous literature.

R1: "Also, the paper is not well organized. The intro clearly outlines 3 questions to be addressed. It would make sense to me, if the methods, results, and discussion followed that order. Instead, section 4.1 addresses section 3.2 which addresses question 1. Section 4.3 addresses question 2, but question 2 does not have a methods or results section."
Authors: We will revise the structure of methods and discussion to mirror the order of the research questions. However, we do not think that it will be feasible to separate results related to research question 1 from results addressing research question 2. This is because the results of the dynamic identifiability analysis (research question 2) are used jointly with the global identifiability analysis to obtain identifiable TSM parameters (with and without considering velocity as a calibration parameter). We believe that splitting dynamic identifiability analysis (research question 2) from the results reporting parameter

identifiability (research question 1) will hamper the robustness of the results about the identifiability of TSM parameters. However, to address the reviewer's concerns and improve readability we will iterate clarity and organization. To do so, the research questions at the end of the introduction will be followed by a short paragraph stating how different methods will be used to address the different research questions.

R1: "Finally, the discussion and conclusion are missing an explanation of how to go forward from these findings. Line 535 states that process interpretation and parameter evaluation should be used with caution, but how do we address that? What are the next steps?"
Authors: We will include a statement addressing this in the revised version of the manuscript. Namely, we will indicate how the adopted modelling strategy can improve parameter evaluation and process interpretation for mathematical modification of the classical formulation of TSM (such as 2-storage zones TSM (Choi et al., 2000), or TSM including sorption kinetics for reactive tracers (Gooseff et al., 2005; Kelleher et al., 2019)).

R1: "The study is novel and can be beneficial for those studying hydrologic exchange in river networks and using tracer experiments, but this paper would greatly benefit from some restructuring and re-writing for improved readability and explanation of methods and results."
Authors: We thank R1 for the supportive feedback and for highlighting the weakness of the manuscript. We will rework the structure as indicated above and revise accurately both the terminology and the verbosity in every section of the text.

R1: "Specific things to address are listed below:

First paragraph of intro is confusing. You mention modeling, then experiments, then talk about issues with modeling again. I think it's worth re-organizing in the following way:

- Understanding transport along river networks is important
- One way is with experiments
- However, current models to describe the processes seen from experiments have contradictory results
- So, it is unknown how informative modeling is"

Authors: Thank you very much on this. We fully agree. We will modify the introduction as suggested.

R1: "Lines 67-73 is jargon heavy and phrasing is clunky."
Authors: We will reformulate the respective sections.

R1: "Sentence 103-104, repetitive".
Authors: As suggested, we will remove the indicated sentence.

R1: "The whole paragraph starting at 113 is confusing."
Authors: We will accurately revise and reformulate the paragraph.

R1: “Also unclear on if the results make sense in terms of physical processes and our current understanding or if they’re spurious relationships (ie non-id A_TS coupled with ID alpha, and when v=vpeak the reverse of that)”
Authors: Our TSM results are consistent with the general understanding of the water movement in the investigated stream reach during the tracer experiments. This is because both the measured groundwater table for the stream reach and the obtained TSM transport metrics excluded any relevant contribution of hyporheic exchange on solute transport during the performed experiments. In the discussion, we will improve the relevant section on the interpretation of the TSM parameters and the derived physical processes in relation of the current understanding of the physical processes at study site. Non-identifiable TSM results indicated non-identifiable A_TS coupled with identifiable alpha, and when v=vpeak the reverse of that, however we do not believe the observed relationship are spurious. This is because other studies also found alpha and A_TS to be both non-identifiable when v=vpeak (Ward et al., 2017, Kelleher et al., 2019).

R1: “Should review and cite Rathore et al., 2021, “On the Reliability of Parameter Inferences in a Multiscale Model for Transport in Stream Corridors”. I believe this paper aligns with your study and might provide some further insight.”
Authors: We thank R1 for the suggested reference that will surely support our discussion.

R1: “No explanation on global identifiability vs dynamic identifiability”
Authors: We will improve the definition of global identifiability analysis and dynamic identifiability analysis in the revised methods section.

R1: “Should reread Gooseff et al., 2005 and update the sentence starting at line 475 as the statement is incorrect as it stands.”
Authors: We agree with R1, as this statement was about sensitivity of transient storage parameters that was not the object of study of Gooseff et al., 2005.

R1: “Figure 8, what is DYNIA analysis? This is not previously explained.”
Authors: DYNIA is the “dynamic identifiability analysis”. We will replace the acronym.