

Dear Editor,

Thank you for the opportunity to review the revised manuscript. The changes made by the authors have clearly improved the paper's quality, and I appreciate the effort, particularly in clarifying the theoretical background on the modelling.

However, several areas still need refinement for optimal clarity and precision in the overall narrative. This is particularly unfortunate, as many relate to points raised in my previous review, such as vague and imprecise language leading to inaccurate hydrological statements. I recommend consistently using the same terminology. For example, always referring to the SAS "framework" or "function" uniformly and correctly distinguishing between "groundwater" and "groundwater storage."

My major concerns at this stage are as follows:

- Persistent vague and imprecise language throughout the manuscript. I recommend a thorough language review to enhance readability.
- Unclear calibration procedure: Was the bucket model calibrated first against streamflow, followed by calibration of the transport model against stable water isotopes? I recommend explicitly explaining these steps.
- Some results sections remain difficult to understand, making it challenging to grasp the main messages. I recommend streamlining these for better flow (see points below).
- I appreciate the addition of a discussion section titled "Implications." However, the section does not contain any actual implications for me. To improve this aspect, I recommend discussing why and how the results matter for water quality, how the approach could apply to other catchments beyond the discussed uncertainties (e.g., whether the a priori assumptions here need adjustment per catchment), and in which catchments (especially regarding active/passive storage dynamics) similar or distinct outcomes might be expected.

I have also raised several minor points which I believe are relevant to improving the manuscript. Some of these concern language clarity and style, where the final decisions are left to the authors.

- Line 1: "Preferential flow paths in hydrological systems (e.g., macropores or subsurface pipe networks)". Macropores/pipe networks are not systems. Please clarify.
- Line 4: Specify "unsaturated zone and groundwater storage" or "groundwater aquifer"? Current wording is incorrect.
- Line 6: Use "hypothesize" (present tense).
- Line 7: Clarify "this effect". Replace "represented through" with "studied with".
- Line 8: Please use "describe" instead of "specify".
- Line 9: "function for the unsaturated zone...": Vague. Consider "functions describing how flow paths from unsaturated/groundwater...".
- Line 14: Delete "where r values...." (no novelty); "corresponding" unclear.
- Line 18: Please introduce "passive groundwater storage" concept earlier.
- Line 18: Consider deleting "with r...." (not essential for abstract).
- Line 20 ff.: Main message unclear; please revise for focus.
- Line 24: Delete "actually".
- Line 28: "Processes" misused. Likely means preferential flow paths?
- Line 37 ff.: Unclear key message; consider deleting.
- Line 43: "Simpler": Compared to what? Maybe delete?

- Line 44: Please clarify "top-down". "Groundwater flow" means streamflow contribution?
- Line 46: Reposition "(transit time, TT)". Delete "statistical". Revise sentence and link to next.
- Line 49: Water flows above, not through, surface. Clarify "their".
- Line 51: Replace "catchment wide input output signals of tracers" with "measured tracer signal". Start new paragraph before "Many studies...".
- Line 55: "Its long-term storage": Vague.
- Line 57 ff.: Why? Meaning unclear. Please add reference.
- Line 59: SAS function definition incorrect due to vagueness.
- Line 63: "Vary over time" restates time-variable SAS.
- Lines 71–82: Unclear key message and "chosen mixing assumptions". Please specify.
- Line 83: Delete "indeed".
- Line 92: Please delete or explain "the conceptualization of Zuber (1986)". Currently unclear.
- Line 93: Use "can be" instead of "is typically".
- Line 98: Please clarify SAS assumptions earlier in introduction.
- Line 99: Please consider using "Applying" instead of "However, adopting...".
- Line 100: Beven citation is the wrong reference here. Please rephrase. The word "Consequently,...." is not connecting a logical consequence here. Please clarify.
- Lines 105–112: Vague, especially last sentence.
- Line 113: Introduce "shape" earlier. "process(es)" misused.
- Line 116: Please use "younger" (not "young"). Please use "described by" (not "through"). Applies manuscript-wide.
- Line 117: "Catchment-scale" is incorrect here (because this sentence refers to streamflow-linked SAS?). Please check third research question for clarity.
- Line 119: Specify model. Please use "fit measured" (not "reproduce").
- Line 128: Remove one "study".
- Line 133: Use "geology of the catchment" (not "area's").
- Section 2.1.: Report soil distribution % consistently for both catchments (or none).
- Lines 143–146: Poor writing; please reformulate.
- Line 165: Please revise title. A tracer model is also a hydrological model.
- Line 166 ff.: Unclear. Please reformulate.
- Line 168: Define "fast response storage".
- Line 177: Please clarify calibration sequence (hydrological model then tracer model?). Please address overcalibration risk.
- Line 178: Use "trace" (not "route").
- Line 192: Which storage do you refer to?
- Figure 2: Please define all letters.
- Line 207: Please replace "binds".
- Line 222: Please justify fixing beta at 1. While reducing calibrated parameters is understandable to avoid overfitting, the specific choice of beta (and value 1) appears arbitrary without physical or conceptual reasoning (e.g., prior studies or theoretical basis). Explicitly state here that alpha was varied during calibration. Initially, it seemed both were fixed at 1 (implying uniform distribution), which would undermine the SAS function's purpose and question the entire approach, as uniform selection requires no SAS modeling.
- Line 227: Please define "outfluxes"(not used before).
- Line 228: Please use "interactions" (not "complexity").
- Line 229: Clarify "outflow" vs. prior "outflux".

- Line 240: Why isn't overland flow considered when $S_r/S_{r,max} > 1$? This seems physically plausible, so if there is a specific reasoning or threshold concept behind this choice, please clarify it.
- Line 264: Use "spin-up" (not "warm-up").
- Line 293: Clarify "fixing".
- Line 298: Please reformulate "It should be noted....".
- Fig. 3 caption: Define "stepwise analysis" (Is this the sensitivity analysis?).
- Lines 310–314: Reformulate for clarity. It is conceptually confusing to first state that passive storage does not contribute to streamflow, then claim it influences streamflow age composition. Please explain the mechanism.
- Line 315: Please use "based on values" (not "to cover the range").
- Line 343: Specify "main features".
- Line 360: Use "sensitivity analysis" consistently (not "experiments").
- Line 375: Please reformulate "SAS shape parameter lower bound".
- Line 397 ff.: Specify where shown.
- Table 1: Use "parameterizations" (not "variation").
- Section 4.1.: Consider deleting this section. While it reads well, the conclusion (line 462) is not supported by the discussion, as the model was designed with catchment-specific assumptions tailored to observations—thus validating against those same data does not demonstrate generalizability or independence
- Line 474 ff.: Please delete repetition.
- Line 482: Please soften: "This suggests...." (because this is not measured).
- Line 486: Please add "to streamflow".
- Line 493: Use "contributions to streamflow". Please define "correlation strength".
- Line 505: The current consequence reads too technically, resembling a result rather than a broader implication. Please expand to discuss wider impacts, such as applications to water quality modelling or transferability to other systems.
- Section 4.3: This section lacks a clear key message and reads like a results summary rather than discussion (e.g., no interpretation, implications, or context). Consider deleting or rewriting to include analysis of findings' meaning and broader relevance.
- Line 526: Please restate the meaning of "fell below 1%".
- Line 537: Please use "TTD".
- Line 539: "Under uniform...": Please delete this sentence, as it repeats results. End the paragraph with a strong final statement summarizing key insights instead.
- Section 4.5: Please rewrite this section for better flow and clarity. Currently, it reads poorly (jumpy, lacks cohesion) and fails to convince why the hydrological community needs a model for preferential flow path contributions. Please specify where, when, and why such modeling is essential (e.g., water quality prediction, solute transport, extreme events). Add a clear take-home message.