Please find below our responses to the comments by the Reviewer. Referee comments are shown in black. Authors replies are in blue

This manuscript investigates the influence of soil moisture and precipitation intensity on quick flow transit times in a flashy agricultural catchment. By utilizing $\delta 18O$ tracer data and enhanced SAS function modeling, the manuscript highlights the importance of accounting for both factors to improve the understanding of quick flow generation and its time scale. While the study has the potential to contribute to the literature, several aspects require improvement to better emphasize the unique contributions and significance of the work.

We thank the reviewer for the positive and constructive feedback, which will help us to improve our work. Below, we outline how we consider the issues raised by the reviewer and the changes we intend to make.

General Comments: The abstract needs further refinement to clearly articulate the study's novelty and main findings. Greater emphasis should be placed on the hypothesis of incorporating precipitation intensity into SAS functions and its significance. Additionally, the practical implications of the findings, such as their potential contribution to hydrological modeling and water management strategies, should be explicitly discussed.

We thank the reviewer for this suggestion. In the revised abstract, we will explicitly highlight the novel aspect of incorporating precipitation intensity into the SAS functions and how this helps refine our understanding of fast flow processes. We will also clarify the significance of this approach for hydrological modeling, particularly in improving transit time estimations and streamflow tracer predictions.

In the introduction, the discussion on defining the SAS function shape solely based on soil moisture is limited and does not adequately capture the complexity of hydrological responses in catchments. This section should expand on the rationale for incorporating precipitation intensity as an additional factor. Furthermore, the introduction would benefit from a more structured conclusion that explicitly presents the study's hypothesis and expected outcomes to provide a clearer sense of direction for readers.

We agree with this comment. We will revise the Introduction to provide a more comprehensive rationale for including precipitation intensity as an additional factor in shaping the SAS functions. Specifically, we will elaborate on how precipitation intensity can influence rapid flow processes (such as infiltration excess, saturation excess overland flow, and agricultural tile drain flow) and its interplay with soil moisture in generating quick flow and shorter transit times. We will also strengthen the concluding paragraph of the Introduction by clearly stating our hypothesis that incorporating precipitation intensity alongside soil moisture for parameterizing time-variable SAS functions will lead to more accurate representations of tracer dynamics in catchments with significant overland flow. Furthermore, we will address the following research questions:

1. *How does formulating the SAS function based solely on soil moisture reflect the tracer simulation in the catchment and the inferred transit times?*
2. *How does formulating the SAS function based on soil moisture conditioned by precipitation intensity affect the tracer simulation in the catchment and the inferred transit times?*

The results section does not sufficiently highlight the study's innovative aspects. Greater emphasis should be placed on demonstrating how incorporating precipitation intensity into the SAS function improves tracer simulation and advances the understanding of quick flow processes.

We appreciate the reviewer's concern regarding the need to highlight the study's innovative aspects in the Results section. We will strengthen this section by explicitly illustrating how tracer simulations for preferential flow differ between the two scenarios. A new figure will be included to demonstrate the model's ability to represent different patterns of $\delta^{18}O$ in simulated preferential flow, thereby highlighting the improvements gained when incorporating precipitation intensity into the SAS function and how this advances our understanding of quick flow processes. Specifically, we will further compare the performance of the precipitation-intensity-based model against the soil-moisture-only model. We will emphasize how these improvements link to specific hydrological processes, such as infiltration-excess overland flow and tile drain flow, thereby explaining why the tracer signal is more aligned with precipitation under high-intensity events.

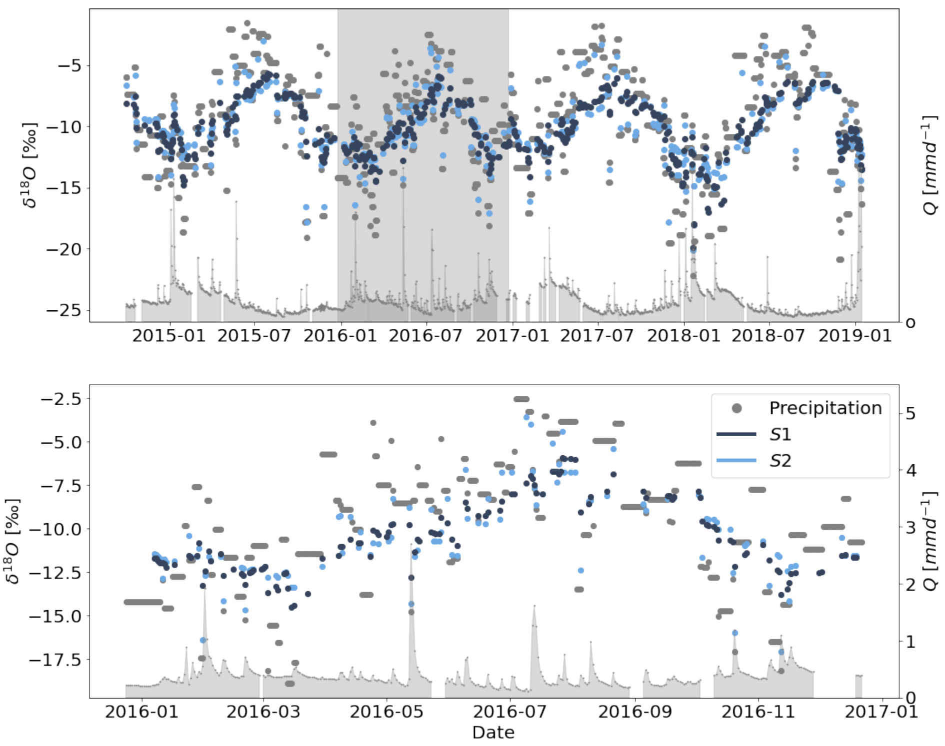

Figure 1: $\delta^{18}O$ simulations from preferential flow in the model under two scenarios: Scenario 1 (S1, dark blue dots), where the SAS function is based solely on soil moisture, and Scenario 2 (S2, light blue dots), where it additionally accounts for precipitation intensity. In S1, the $\delta^{18}O$ signal is more dampened, indicating a stronger smoothing effect of soil moisture on the tracer input. In contrast, S2 produces $\delta^{18}O$ responses more closely aligned with the precipitation input, reflecting a more direct contribution of event water to streamflow.

The broader applicability of the findings to different types of catchments should be discussed. Expanding on how the proposed approach could be generalized to catchments with varying hydrological characteristics would enhance the study's relevance and impact.

We appreciate this comment and will include a discussion how our proposed approach could be transferred to catchments exhibiting similar hydrological characteristics (other catchments where fast flow is of relevance). Specifically, we will highlight how factors such as land use, and soil properties, influence the role of precipitation intensity in rapid runoff generation. By outlining these considerations, we aim to demonstrate the broader applicability of our findings and how they could inform future studies or modelling strategies in varied catchments

The conclusions should include a more detailed discussion of the underlying mechanisms and the broader implications of the findings. While the conclusion mentions the potential for contributing to water management strategies, it remains vague. Specific examples of how the results could be applied in practice would make the conclusions more compelling and actionable.

We agree with this recommendation highlighting our findings (e.g., how fast flow paths and precipitation intensity interplay drive rapid transit times). We will also highlight specific examples of practical applications such as informing agricultural drainage management, refining flood forecasting tools, and guiding land-use planning to mitigate runoff peaks.

Specific Comments L33-34: Clarify the meaning of "Flow process promotes contribution of precipitation to the stream." Additional explanation is needed.

We agree. We will revise this sentence in the manuscript to clarify that the "flow process facilitates the contribution of precipitation to the stream" refers to rapid flow pathways—such as infiltration-excess overland flow, preferential flow through macropores, and tile drain flow—that allow precipitation water to bypass much of the soil matrix and reach the stream with minimal storage or mixing.

Lines 102-109 lack logical clarity, with an abrupt shift from discussing preferential flow in headwater catchments to emphasizing quick flow responses. Refocus the section for better coherence.

We appreciate this comment and will revise the paragraph for better coherence. Specifically, we will restructure lines 102–109 to create a smoother transition from discussing preferential flow in headwater catchments to highlighting the broader range of rapid flow responses (e.g., infiltration-excess overland flow). We will clarify that while preferential flow is often encapsulated in SAS functions through soil-moisture-dependent mechanisms, rapid runoff can also occur when precipitation intensities exceed the infiltration capacity. This revision will establish a logical progression leading to our hypothesis that incorporating precipitation intensity in SAS functions can improve the representation of tracer dynamics.

L117: The citation is unnecessary in this context.

Thank you for pointing this out. We will remove the citation at Line 117 to maintain conciseness and clarity in the text.

L149: What does "event intensities" refer to? Are the event intensities specified as 5 mm/h? The phrase "at the end of with that of the following event" is unclear. Please revise for clarity.

Thank you for the comment. We will revise the explanation for clarity. The following revision will be made to the manuscript: Once a 0.25, L sampling bottle was filled (corresponding to 5, mm of precipitation), the sampler switched to the next bottle. If the rainfall intensity was too low to fill a bottle within a single event, some precipitation from the end of one event could mix with precipitation from the start of the following event in the same bottle.

L155: Does “Length of event” refer to the event duration? Additionally, how does the “event length” influence the adjustment of sampling frequency? Provide more details.

Yes, the “length of the event” refers to the event duration. Specifically, to influence the adjustment of sampling frequency for longer events, the sampling could be spaced to cover the full duration without exceeding bottle capacity. We will replace "length" with "duration" in the revised manuscript.

L254: Check and revise “Equation 2727” as it appears to be an error.

Thank you for pointing this out. We will correct “Equation 2727” to its intended reference “Equation 27”.

L423: Confirm whether “6.53%” refers to Scenario 2.

Yes, the value “6.53%” refers to Scenario 2. We will revise the text to make this reference clearer.

L432: Avoid repetition of “based on.”

We will revise the sentence at Line 432 to remove the repeated phrase “based on,”

L445: Delete “as” for grammatical accuracy.

We will delete “as” for grammatical accuracy

L545: The word “stable” is repeated unnecessarily. Remove one instance.

Thank you for highlighting this repetition. We will remove the extra instance of the word “stable” to improve readability and clarity.

L571: Provide more explanation regarding the mechanism by which “agriculturally used land tends to seal at the surface during heavy events.” This statement requires elaboration for better understanding.

We will clarify that agricultural soils, particularly those with intensive tillage or limited vegetative cover are prone to surface sealing (Laloy and Bielders, 2010) during heavy rainfall events (e.g a reduction in infiltration capacity from heavy machinery, soil erosion processes). The impact of raindrops can break down soil aggregates at the surface, leading to the formation of a thin, compacted soil layer (i.e., a “soil crust”) that reduces infiltration capacity (Blöschl, 2022). This crust formation can be more pronounced in soils with higher silt content or weak aggregate stability, thereby favoring overland flow and quick runoff generation during heavy precipitation.

L668: The statement “assisting in developing effective water management strategies” is too vague. Include specific examples of potential real-world applications to make this claim more concrete and persuasive.

In the revised manuscript, we will provide examples of how these findings can inform effective water management strategies in agricultural catchments. For instance, by pinpointing periods or conditions under which precipitation intensity triggers rapid flow through tile drains and preferential pathways, managers could better schedule fertilizer applications to minimize nutrient leaching and reduce water quality deterioration. Similarly, insights into quick flow processes can guide the placement and timing of agricultural drainage systems to mitigate peak flows, inform stormwater management interventions (e.g., retention ponds or buffer strips) to reduce runoff peaks, and land-use practices to prevent or minimize the direct contribution of event water to streams. These practical examples will underscore how our improved understanding of rapid flow pathways can lead to tangible benefits in real-world water management scenarios.

In addition to addressing the specific comments above, it is recommended to carefully proofread the manuscript to ensure proper grammar, sentence structure, and clarity.

We fully acknowledge the importance of clear and concise writing. As suggested, we will meticulously proofread the manuscript to address any grammatical or structural issues and to enhance the overall clarity of the text.

References

Blöschl, G.: Flood generation: process patterns from the raindrop to the ocean, Hydrology and Earth System Sciences, 26, 2469–2480, 2022.

Laloy, E. and Bielders, C. L.: Effect of intercropping period management on runoff and erosion in a maize cropping system, Journal of environmental quality, 39, 1001–1008, 2010.