List of Changes

1. Line 25 of page 2: Revised the sentence to include "are" after "magnitude" for grammatical accuracy, in response to Comment 1.
2. Lines 30-32 of page 2: Removed the unclear sentence and revised the paragraph for improved clarity and logical flow, in response to Comment 2.
3. Lines 31-32 of page 2: Clarified GWL thresholds by stating "When the GWL surpasses a critical threshold," in response to Comment 3.
4. Line 37 of page 2: Replaced "volume" with "magnitude", in response to Comment 4.
5. Line 61 of page 3: Clarified that the 113 mm threshold pertains to Martínez-Carreras et al. (2016)'s study area, in response to Comment 5.
6. Line 115 of page 5: Removed the unnecessary word "at" for grammatical accuracy, in response to Comment 6.
7. Line 116 of page 5: Added the missing unit "m" after "676" for clarity, in response to Comment 7.
8. Lines 130 & 135 of page 6: Standardized the hydraulic conductivity units to SI units (m/s) for consistency throughout the manuscript, in response to Comment 8.
9. Line 143 of page 7: Added the missing unit "m" after "5" for clarity, in response to Comment 9.
10. Line 145 of page 7: Fixed spacing between the sentence and subsection title, in response to Comment 10.
11. Lines 146 & 148 of page 7: Revised the expression “spanning 2013-2023” to “spanning eleven years, from 2013 to 2023,” and added measurement units “m” after “700”, “900”, and “1000” for clarity and consistency, in response to Comment 11.
12. Lines 149-150 of page 7: Clarified spatial averaging of rainfall data from six gauges per 10-minute interval, in response to Comment 12.
13. Line 160 of page 7: Clarified that SWC data were spatially averaged at each 10-minute interval, in response to Comment 12.
14. Lines 162-177 of page 8: Revised the description of groundwater level normalization, in response to Comment 14.
15. Lines 165-166 of page 8: Removed redundant mention of groundwater level normalization, in response to Comment 13.
16. Lines 165-174 of page 8: Added an explanation to reinforce the choice of using an inverted I_G axis in figures, in response to Comment 32.
17. Lines 182-186 of page 8: Revised the definition of “event”, in response to Comment 15.
18. Line 191 of page 9: Removed “, HESS” for accuracy, in response to Comment 16.
19. Line 195 of page 9: Replaced “&” with “and” for consistency, in response to Comment 17.
20. Lines 196-201 of page 9: Merged two redundant sentences for conciseness, in response to Comment 19.
21. Lines 194-195 of page 9: Removed redundant lines to avoid repetition, in response to Comment 18.
22. Line 203 of page 9: Corrected "was" to "were" for grammatical accuracy, in response to Comment 20.
23. Line 205 of page 9: Changed "The" to lowercase, in response to Comment 21.
24. Lines 268-269 of page 12: Clarified statistical expression by adding standard error and refining

the confidence interval, in response to Comment 22.

25. Lines 273-274 of page 13: Updated the caption of Figure 5, in response to Comment 23.
26. Line 305 of page 15: Added "which" before "represents" for grammatical clarity, in response to Comment 24.
27. Line 306 of page 15: Removed "Analysis revealed that" to enhance conciseness, in response to Comment 25.
28. Line 352 of page 18: Revised "0.13-0.26" to "from 0.13 m^3/m^3 to 0.26 m^3/m^3" for improved readability, in response to Comment 26.
29. Line 367 of page 18: Replaced "0-2 h" with "less than 2 h", in response to Comment 27.
30. Lines 382-384 of page 19: Rephrased the expression regarding I_G peak rates for clarity and correctness, in response to Comment 28.
31. Line 399 of page 21: Capitalized “Pressure” in “pace. pressure-driven” for proper grammar, in response to Comment 30.
32. Lines 418-419 of Page 21: Replaced “of 10-30 meters” with “varying from 10 m to 30 m”, in response to Comment 31.
33. Lines 442-444 of page 23: Clarified the rationale for the inverted I_G axis in Figure 12’s caption, in response to Comment 32.
34. Lines 477 & 479 of page 24: Converted values from days to hours for clarity and consistency, in response to Comment 33.
35. Figure 11: Standardized the vertical axis unit in Figure 11 to d^{-1} for consistency, in response to Comment 29.
36. Figure 13: updated the x-axis from days to hours.

Note: The above changes are indicated using track changes in the marked-up revised manuscript.

Response to Editors' Comments

Dear Editor,

Thank you for your valuable comments and suggestions on our manuscript. We have carefully reviewed your feedback and made the necessary modifications to the manuscript. The detailed corrections are listed below, point by point:

Comment 1:

Line 25. Expression “timing and magnitude further modulated” should be corrected, possibly by adding “are” after “magnitude”.

Response 1:

Thank you for your careful review. We appreciate your suggestion regarding the expression on Line 25. We have revised the sentence to include "are" after "magnitude" for grammatical accuracy. The updated sentence now reads:

"Delayed stormflow is initiated when SWC exceeds the soil’s water storage capacity, while its timing and magnitude are further modulated by GWL fluctuations." **(Page 2, Line 25)**

Comment 2:

Lines 30 & 31. Sentence “Concurrently, the effective connectivity between the stream channel and adjacent hillslopes increases in the vertical dimension” is very unclear to me.

Response 2:

Thank you for your insightful feedback. We sincerely apologize for the lack of clarity in the original sentence. Upon re-evaluating the context, we agree that the phrase “Concurrently, the effective connectivity... increases in the vertical dimension” introduces redundancy and may not directly contribute to the core mechanistic explanation in this section.

The key intended meaning was to highlight that rising groundwater levels (GWL) vertically expand the zone of hydraulic connectivity between hillslopes and the stream, thereby enhancing lateral groundwater contributions. However, since the preceding sentence already explains how “enhanced hydraulic conductivity facilitates lateral movement of shallow groundwater toward the stream channel” (which inherently depends on vertical connectivity expansion), we recognize that explicitly mentioning "vertical dimension" here could be redundant.

To streamline the logic and improve clarity, we have removed the sentence entirely. The revised paragraph now reads:

“As GWL rises, enhanced hydraulic conductivity facilitates the lateral movement of shallow groundwater toward the stream channel, generating delayed stormflow. When the GWL surpasses a critical threshold, GWL responses across the watershed become synchronized, significantly boosting groundwater discharge and reducing lag times.” **(Page 2, Lines 30-32)**

This revision maintains the focus on the causal chain (GWL rise → lateral flow → synchronization → discharge dynamics) while eliminating potential ambiguity. We believe this adjustment strengthens the conciseness and scientific rigor of the abstract.

Thank you again for your constructive critique. We are happy to refine this further if needed.

Comment 3:

Line 31. Expression “At higher GWL thresholds” is unclear: non threshold has been mentioned so

far.

Response 3:

Thank you for your careful review and insightful comment regarding Line 31. We acknowledge that the phrase "higher GWL thresholds" was unclear as no prior threshold had been explicitly mentioned. To improve clarity, we have revised the sentence as follows:

"When the GWL surpasses a critical threshold, GWL responses across the watershed become synchronized, significantly boosting groundwater discharge and reducing lag times." **(Page 2, Lines 31-32)**

Comment 4:

Line 36. Is “volume” the right word? May be, “discharge”?

Response 4:

Thank you for your insightful comment on Line 36. After careful consideration, we have replaced "volume" with "magnitude" as it more accurately reflects the overall response of delayed stormflow, including both peak intensity and cumulative effects. We appreciate your valuable feedback, which has helped us improve the clarity and precision of our manuscript. **(Page 2, Line 37)**

Comment 5:

Lines 58 & 59. Remark “a delayed peak only occurred when watershed storage reached a critical threshold of 113 mm” is given here as a result of general validity everywhere. I am afraid that it refers to a specific study area.

Response 5:

Thank you for your valuable comment. We agree that the statement regarding the threshold of 113 mm is specific to the study area of Martínez-Carreras et al. (2016). We have revised the text to clarify that this threshold value is based on their findings in that particular watershed, and we have added that the underlying processes behind this threshold are not yet fully understood. The revised sentence now reads:

"For instance, Martínez-Carreras et al. (2016) found that a delayed peak only occurred when watershed storage reached a critical threshold of 113 mm in their specific study area." **(Page 3, Line 61)**

Comment 6:

Line 112. Word “at” should be erased, shouldn’t it?

Response 6:

Thank you for your helpful comment. You are correct that the word "at" should be erased. We have revised the sentence accordingly. **(Page 5, Line 115)**

Comment 7:

Line 113. Measurement units “m” should be added after “676”.

Response 7:

Thank you for your careful review. We agree with your suggestion and have added the unit "m" after "676" in the revised manuscript. **(Page 5, Line 116)**

Comment 8:

Lines 127 & 132. The same measurement units for hydraulic conductivity should be used throughout the paper. I would prefer the use of SI units, so m/s.

Response 8:

Thank you for your valuable suggestion. We agree that consistent units should be used throughout the paper and that SI units (m/s) are preferable. We have converted all hydraulic conductivity values to m/s for consistency. The revised sentences now read:

"The soils in XEW are primarily brown earth and cinnamon soils, with depths up to 1.5 m and an average saturated hydraulic conductivity of 1.25×10^{-5} m/s. [...] Slug tests estimated the saturated hydraulic conductivity of weathered granite to range from 6.02×10^{-8} m/s to 1.34×10^{-5} m/s." **(Page 6, Lines 130 & 135)**

Comment 9:

Line 139. Measurement units "m" should be added after "5".

Response 9:

Thank you for your careful review. We agree with your suggestion and have added the unit "m" after "5" in the revised manuscript **(Page 7, Line 143)**

Comment 10:

Lines 140 & 141. "2.3 Meteorological and streamflow 140 data collection" is the title of the next subsection.

Response 10:

Thank you for pointing this out. We acknowledge the formatting issue and have corrected it by ensuring proper spacing and separation between the sentence and the subsection title. **(Page 7, Line 145)**

Comment 11:

Line 142. Expression "spanning 2013-2023" should be rephrased, possibly as "spanning eleven years, from 2013 to 2023,".

Line 143. Measurement units "m" should be added after "700", "900", and "1000".

Response 11:

Thank you for your helpful suggestions. We have revised the sentence to improve clarity and consistency. The updated version now reads:

"Meteorological data spanning eleven years, from 2013 to 2023, were collected from four GRWS100 automatic weather stations (WS700, WS900, WS1000, and WS1100), positioned at elevations of 700m, 900m, 1000m, and 1100 m, respectively." **(Page 7, Lines 146 & 148)**

Comment 12:

Lines 145 & 155. Which kind of average? Space or time average? In the latter case, which time interval has been considered for the averaging?

Response 12:

Thank you for your insightful comment. The rainfall data were spatially averaged across six tipping-bucket rain gauges at each 10-minute interval. The revised sentences now read:

"Rainfall was recorded at 10-minute intervals using six tipping-bucket rain gauges near the weather stations, and the data were spatially averaged across the gauges for each time step for analysis." **(Page 7, Lines 149-150)**

The SWC data were also spatially averaged across multiple monitoring sites at each 10-minute interval. The revised sentences now read:

"Measurements were recorded every 10 minutes, and the arithmetic mean of SWC values across the monitoring sites was computed for each time step." **(Page 7, Line 160)**

Comment 13:

Lines 161 & 162. Sentence "Groundwater levels were normalized following the method described by Detty and McGuire 161 (2010)" repeats what was written at lines 158 & 159.

Response 13:

Thank you for your careful review. We acknowledge the redundancy and have removed the repeated sentence at lines 158 & 159 to improve clarity and conciseness. **(Page 8, Lines 165-166)**

Comment 14:

Lines 162 & 163. If I understood correctly, "the lowest recordable depth of the instrument" depends on the sensor position, so it is a factor related to the experimental setup, not a physical property of the subsurface.

Response 14:

Thank you for your insightful comment. We agree that the lowest recordable depth of the instrument is determined by sensor placement. However, the wells used in this study were drilled to sufficient depths to capture long-term groundwater fluctuations, ensuring that the observed groundwater variations reflect actual subsurface hydrological processes rather than limitations imposed by the experimental setup.

To improve clarity, we have revised the description of our groundwater level normalization approach as follows:

"GWLs (below the ground surface, hereinafter referred to as bgs) were observed in six boreholes distributed across the hillslopes. Hourly data were recorded using HOBO capacitance water level loggers. To facilitate comparisons across wells with varying absolute GWL ranges, we normalized the GWLs following the method described by Detty and McGuire (2010). Specifically, for each well, GWLs were normalized to their total observed range, assigning a value of 0 to the shallowest GWL and 1 to the deepest. The arithmetic means of these normalized values across all boreholes, referred to as the groundwater index (I_G), effectively represent the overall GWL dynamics in the watershed. Given that lower IG values indicate higher GWLs, and higher IG values correspond to deeper GWLs, figures presenting IG trends (e.g., Fig. 12 and Fig. A1) use an inverted vertical axis to align visually with hydrological intuition." **(Page 8, Lines 162-177)**

This revision clarifies that the normalization was applied to the entire range of observed GWLs, rather than being constrained by the lowest recordable depth of the instrument. The minimum observed GWL at each site is influenced by local geological and hydrological characteristics, such as bedrock depth and subsurface connectivity, making it a meaningful hydrological parameter rather than merely an experimental constraint. Similar normalization approaches have been widely used in previous studies (e.g., Detty & McGuire, 2010) to facilitate cross-site comparisons of

groundwater dynamics. We appreciate your feedback, which has helped us improve the clarity of our methodology.

Comment 15:

Lines 172 & 173. The definition of "event" should be better rephrased. In particular, the rainwater intensity is considered as the hourly averaged value or the value measured at the sampling period (10 minutes)?

Response 15:

Thank you for raising this important clarification. We have revised the definition to explicitly specify the temporal scale of rainfall intensity measurement. The modified text now reads:

"Rainfall events were identified using an intensity-based automatic algorithm (Tian et al., 2012) that defines an event as periods with hourly-averaged rainfall intensity exceeding 0.1 mm/h, separated by at least six consecutive hours with intensities below this threshold. Events with cumulative rainfall >5 mm were retained for analysis." **(Page 8, Lines 182-186)**

This revision aligns with the data processing methodology stated in Section 2.4:

"Rainfall, streamflow, and SWC data were aggregated to hourly intervals for temporal alignment with GWL measurements." **(Page 8, Line 178)**

Comment 16:

Line 177. ", HESS" should be erased.

Response 16:

Thank you for your suggestion. We agree with your comment and have removed "HESS" for accuracy. **(Page 9, Line 191)**

Comment 17:

Line 181. "&" should be substituted with "and" to be consistent throughout the whole paper.

Response 17:

Thank you for your careful review. We agree with your suggestion and have replaced "&" with "and" for consistency. **(Page 9, Line 195)**

Comment 18:

Lines 184 & 185. Erase these lines, they repeat lines 180 & 181.

Response 18:

Thank you for your careful review. We agree with your comment and have removed the redundant lines to avoid repetition. **(Page 9, Lines 194-195)**

Comment 19:

Lines 182 & 183, 186 & 187. These sentences basically repeat the same concepts and should be merged.

Response 19:

Thank you for your valuable comment. We acknowledge the redundancy in our original text and have merged the two sentences for conciseness. The revised sentence now reads:

"Throughout the manuscript, stormflow refers to the total discharge, while event stormflow volume (q_s) is calculated as the total discharge minus baseflow." **(Page 9, Lines 196-201)**

Comment 20:

Line 189. Is “was” correct? May be, “were”?

Response 20:

Thank you for pointing this out. We have corrected "was" to "were." **(Page 9, Line 203)**

Comment 21:

Line 191. Lowercase should be used for “the”.

Response 21:

Thank you for pointing this out. We apologize for the oversight and have corrected "The" to lowercase. **(Page 9, Line 205)**

Comment 22:

Lines 253 & 254. A standard deviation of 0.01158, for 14 data, corresponds to a standard error on the average value of $0.0158/14^{1/2}$=0.004. Therefore, it would be better to write “a mean value of 0.197 ± 0.004 and…”.

Response 22:

Thank you for your meticulous feedback. We sincerely appreciate your attention to statistical rigor and have revised the text accordingly. The corrected sentence now reads:

"The statistical analysis of the stable SWC revealed a mean value of 0.197 ± 0.004 m^3/m^3, with a confidence interval of 0.188–0.207 m^3/m^3." **(Page 12, Lines 268-269)**

Key revisions:

Standard Error Clarification:

Explicitly reported the standard error (SEM) as ±0.004, calculated via $\text{SEM} = \frac{0.0158}{\sqrt{14}} \approx 0.004$.

Confidence Interval Correction:

Recalculated the 95% confidence interval using the *t*-distribution ($t_{0.025,\,13} = 2.16$):

$0.197 \pm 2.16 \times 0.0042 = [0.188, 0.207]$.

Comment 23:

Line 257. The caption should explain what is represented by the blue strip.

Response 23:

Thank you for your comment. The blue strip represents the 95% confidence interval of stable soil water content (SWC), with its upper and lower boundaries ranging from 0.189 to 0.205. We have revised the figure caption for clarity, and it now reads:

“Figure 5. SWC dynamics during different storm events. The blue strip indicates the 95% confidence interval of stable SWC.” **(Page 13, Lines 273-274)**

Comment 24:

Line 288. Pronoun “that” should be added before “represents”.

Response 24:

Thank you for your suggestion. We have revised the sentence by adding "which" before "represents" enhance grammatical clarity. **(Page 15, Line 305)**

The addition of the relative pronoun "which" ensures proper syntax for the non-restrictive clause describing I_G. This revision aligns with grammatical conventions while preserving the intended meaning. We appreciate your attention to detail in strengthening the manuscript's readability.

Comment 25:

Line 289. "Analysis revealed that" can be erased.

Response 25:

Thank you for your suggestion. We have removed "Analysis revealed that" to improve conciseness. **(Page 15, Line 306)**

Comment 26:

Line 335. "0.13-0.26" should be substituted as "from 0.13 to 0.26".

Response 26:

Thank you for your suggestion. We have revised "0.13-0.26" to "from 0.13 m^3/m^3 to 0.26 m^3/m^3" as recommended. **(Page 18, Line 352)**

Comment 27:

Lines 349 to 351. Expressions "0-2 h" and similar should be substituted, possibly as "less than 2 hours".

Response 27:

Thank you for your suggestion. We have replaced "0-2 h" with "less than 2 h," to improve readability. **(Page 18, Line 367)**

Comment 28:

Lines 364 & 365. Expression "a markedly faster rates (0.03 to 0.98/day, mean: 0.38/day) compared to the second peak 364 (0.01 to 0.31/day, mean: 0.07/day)" should be rephrased, possibly as "a markedly faster rate (from 0.03 d-1 to 0.98 d-1, with a mean of 0.38 d-1) than the second peak (from 0.01 d-1 to 0.31 d-1, with a mean of 0.07 d-1)."

Response 28:

Thank you for your valuable suggestion. We have revised the sentence for clarity and grammatical correctness. The updated version now reads:

"The first IG peak exhibited a markedly faster rate (ranging from 0.03 d^{-1} to 0.98 d^{-1}, with a mean of 0.38 d^{-1}) than the second peak (ranging from 0.01 d^{-1} to 0.31 d^{-1}, with a mean of 0.07 d^{-1})." **(Page 19, Lines 382-384)**

Comment 29:

Figure 11. The notation of the measurement units of the principal vertical axis should be corrected (see previous comment).

Response 29:

Thank you for your comment. We have corrected the notation of the measurement units on the principal vertical axis of Figure 11, changing it to d^{-1} for consistency and accuracy.

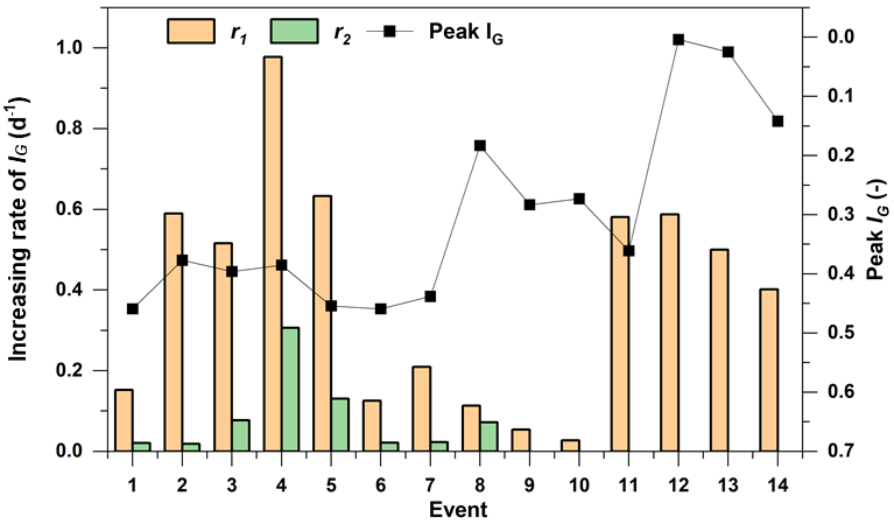

Figure 11. Growth rates of I_G and the maximum I_G value across storm events. r_1 and r_2 denote the ascent rates during the first and second peaks, respectively. **(Page 20, Line 390)**

Comment 30:

Line 379. "pace. pressure-driven" should be corrected. May be, "Pressure" should start with uppercase.

Response 30:

Thank you for your careful review. We have corrected the lowercase "pressure" to "Pressure" to ensure proper grammar and readability. **(Page 21, Line 399)**

Comment 31:

Lines 398 & 399. Expression "of 10-30 meters" should be substituted with "varying from 10 m to 30 m".

Response 31:

Thank you for your suggestion. We have " of 10-30 meters " with " varying from 10 m to 30 m" to improve readability. **(Page 21, Lines 418-419)**

Comment 32:

Figure 12. Figure caption must be rephrased in a more clear way. Why is this figure drawn with the IG axis increasing downwards? I found this choice confusing, when I was reading the comments about what happens for high and low values of I_G.

Response 32:

Thank you for your insightful comment. We acknowledge that the choice to plot I_G with an inverted vertical axis may not have been immediately intuitive to all readers. However, this decision was made to align with the definition of the groundwater index (I_G) in our study.

As described in Section 2.4 (Methodology), I_G is derived from normalized groundwater levels (GWLs) following the approach of Detty and McGuire (2010). Specifically, for each well, GWLs were normalized to their total observed range, where:

- A value of 0 represents the shallowest observed GWL (i.e., highest groundwater level).
- A value of 1 represents the deepest observed GWL (i.e., lowest groundwater level).

Since higher I_G values correspond to lower groundwater tables and lower I_G values indicate higher groundwater levels, we plotted I_G on an inverted axis so that increasing I_G values appear downward. This ensures that the figure visually aligns with hydrological intuition—higher groundwater levels (lower I_G) correspond to greater connectivity and shorter lag times, as discussed in the text.

To enhance clarity and avoid confusion, we will take the following actions:

1. Modify the figure caption to explicitly clarify the rationale for the inverted I_G axis.
2. Add a brief explanation in Section 2.4 (where I_G is defined) to reinforce this choice.

Revised Figure Caption (Figure 12)

"Figure 12. Correlation between peak I_G and the time differences from peak GWL responses on HS1 and HS2 to HS3 ($\Delta t = t_S - t_{S3}$), where t_{S1}, t_{S2}, and t_{S3} are the average lag times of peak GWLs on HS1, HS2, and HS3, respectively. Note that the I_G axis is inverted: I_G is a normalized groundwater index where lower values indicate higher GWLs, and higher values represent deeper GWLs." **(Page 23, Lines 442-443)**

Additional Explanation in Section 2.4 (Methodology) (Revised Text)

"To facilitate comparisons across wells with varying absolute GWL ranges, we normalized the GWLs following Detty and McGuire (2010). For each well, GWLs were normalized to their total observed range, assigning a value of 0 to the shallowest GWL (i.e., highest groundwater level) and 1 to the deepest GWL (i.e., lowest groundwater level). The arithmetic means of these normalized values across all boreholes, referred to as the groundwater index (I_G), effectively represent the overall GWL dynamics in the watershed. Given that lower I_G values indicate higher groundwater levels, and higher I_G values correspond to deeper groundwater tables, figures presenting I_G trends (e.g., Fig. 12 and Fig. A1) use an inverted vertical axis to align visually with hydrological intuition." **(Page 8, Lines 164-177)**

Comment 33:

Lines 453 & 455. Isn't it better to give values in hours rather than in days?

Response 33:

Thank you for your suggestion. We have converted the rainfall duration and peak timing values from days to hours for better clarity and consistency. Accordingly, the relevant sentences now state: "Rainfall durations for the analyzed events ranged from 11h to 40 h. SWC, I_G, and delayed stormflow (q_{2p}) followed a clear sequence in their peak timings relative to rainfall onset. SWC responded rapidly, with its peak occurring 10 h to 50 h after rainfall began, usually coinciding with or slightly after rainfall cessation." **(Page 24, Lines 477 & 479)**

Additionally, we have updated the x-axis of Figure 13 from days to hours to maintain consistency.

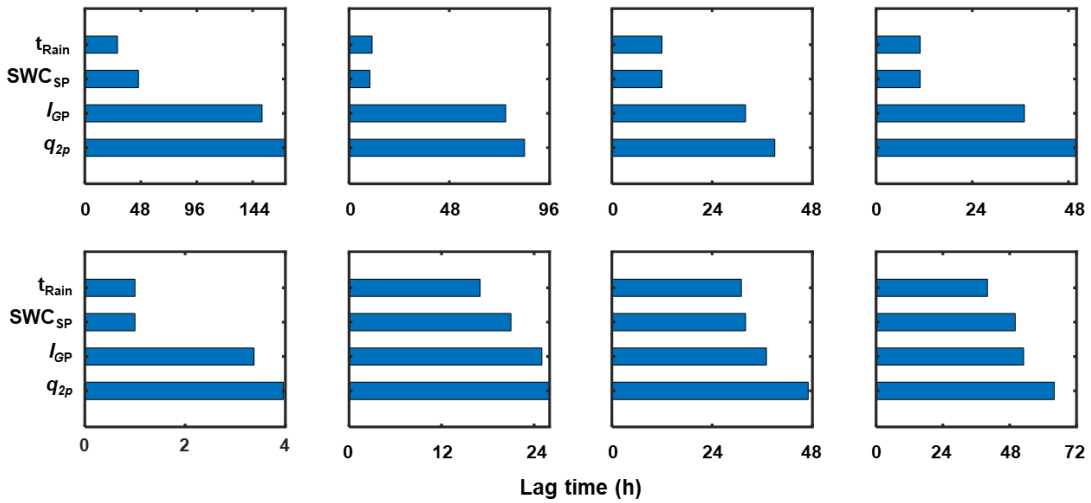

Figure 13. Lag times of maximum SWC and GWL relative to rainfall onset. Each bar indicates the rise and peak times of the corresponding variable, with t_{Rain} indicating rainfall duration. SWC_{SP} and I_{GP} represent the maximum SWC and I_G, respectively, while q_{2p} denotes the delayed streamflow peak. **(Page 24, Line 464)**

The authors sincerely appreciate the editor's valuable feedback. We have thoroughly revised the manuscript to improve clarity, grammar, and fluency. The revised version has been submitted, and we look forward to your evaluation.

Yours
Zhen Cui, Fuqiang Tian
March 7, 2025