Reply to Editor's Comment

Dear Authors,
both reviewers agree that you have significantly improved the manuscript. I am glad to see that!
However, there are still some issues concerning the wording/language as well as some other issues which should be addressed in another round of (minor) revisions.
One of the reviewers has provided detailed comments and suggestions but please also check for wording issues beyond these comments. In the abstract you refer to a resulting bias, it might be necessary to provide some clarification here - what type of bias are you talking about?
Please revise your manuscript according to the reviewer's suggestions.
Wishing you all the best and looking forward to your revised manuscript,
Theresa Blume

Reply:

Dear Theresa,

Thank you for your email and for sharing the feedback from the reviewers. We are delighted that both reviewers acknowledge the significant improvements we have made to the manuscript.

We greatly appreciate the invaluable suggestions provided by the two reviewers during the three rounds of review. We are particularly grateful for Reviewer 1's meticulous editing recommendations. In this revision, we have diligently incorporated Reviewer 1's suggestions and added a new Table S3 for describing the definition and calculation of landscape and rainstorm variables. Also, we conducted a comprehensive review of the vocabulary and grammar throughout the entire manuscript.

In relation to your mention of "bias" in the abstract, we have taken steps to address this concern and provide further clarification. Specifically, we have revised the sentence [L18-20] as follows: "Without considering this contrasting response, which is contingent upon landscape structure, it leads to a misjudgment of the recession nonlinearity in response to rainfall amount and needs further clarification, particularly for use in assessing regional recession in ungauged catchments under climate change."

Many thanks for your patience and handling. If any further questions, please tell us for corrections.

Best regards,
Jr-Chuan (River) Huang

Reply to Reviewer 1 Comments

GENERAL COMMENTS

The third version of this paper, while improved, still contains some unclear statements, and requires additional editing. I provided some editorial suggestions but did not attempt to be thorough.

I recommend this paper be returned to the authors for minor revisions.

Reply: We appreciate the reviewer for providing such constructive and editorial suggestions. We made point-to-point modifications based on these suggestions. In this review, Reviewer #1 raised some comments associated with the definition and calculation of landscape variables. Therefore, we added a new Table S3 in supplementary for keeping the manuscript concise. At the same time, we reconfirmed the tenses and grammar of all the verbs in this text.

LINE-BY-LINE COMMENTS

9-19: The abstract does not sufficiently summarize the study and the significance of the results. It should, for one, give the physical significance of the relationships between the recession parameters (a, b) and the various factors (e.g., L/G, catchment area). For example, it is not enough to only state that the value of b decreases as L/G increases. What is the significance of L/G? What does it represent with regards to what influences the flow of water through the catchment What does it imply in terms of subsurface flow that b decreases as L/G increases?

Reply: The landscape structures can lead to the contrasting response of recession is what we want to highlight. In this regard, we replaced the L/G with the landscape structure to keep the abstract concise. Meanwhile, we understand this comment raised by the reviewer and admit that the significance of L/G to recession is quite important. Therefore, we addressed it in L81-88 and added a new Table S3 in supplementary for describing the definition and calculation of landscape and rainstorm variables.

15-16: Flow-path length and gradient should be defined. Subsurface flow path length? River channel flow path length? Gradient of the river channel? Mean gradient of the catchment? Mean hillslope gradient?

Reply: As mentioned, we removed L/G from the abstract, but addressed the explanation of L/G in L81-88. Table S3 in the Supplementary clarified the definition

and calculation of the variables.

17: Non-linearity of what? “Non-linearity” needs to be defined.
Reply: Rephrased as "recession nonlinearity" for clarification [L17].

21-33: The English usage in the first two paragraphs is often poor and the information is presented in a manner that is difficult to follow. These paragraphs provide very important context for the authors’ study so I think more care should be given towards clearly relaying the information. Currently, it reads as a somewhat unorganized list of results from 4 – 5 studies. Separate paragraphs for effects of landscape structure and rainfall/antecedent storage conditions might help. Separate paragraphs discussing the recession coefficient and non-linearity might also help.
Reply: Based on the influences of topography and rainfall/antecedent moisture conditions, we reorganized this section into two paragraphs as suggested [L29-37] and [L38-46]:

Paragraph 1: “Since aquifers in various landscape units (e.g., hillslopes, riparian areas, streams, etc.) exhibit different hydraulic properties, theoretical works have shown that the streamflow recession parameters depend on the landscape structure or aquifer properties. Specifically, from the aspect of aquifer hydraulics (Rupp and Selker, 2006), spatial heterogeneity (Harman et al., 2009) and drainage network (Biswal and Marani, 2010) have been observed that these recession parameters are influenced by the aforementioned factors. In general, parameter $\hat{a}$ shows a positive correlation with stream length and aquifer slope (Rupp and Selker, 2006), while it exhibits a negative correlation with drainage area, aquifer depth, aquifer heterogeneity (Rupp and Selker, 2006), and inter-hillslope heterogeneity (Harman et al., 2009). On the other hand, parameter b tends to increase with the number of streams (Biswal and Marani, 2010), aquifer heterogeneity (Rupp and Selker, 2006), and inter-hillslope heterogeneity (Harman et al., 2009), whereas it decreases with the total stream length (Biswal and Marani, 2010).”

Paragraph 2: “Additionally, theoretical works have shown that the dependence of streamflow recession parameters on antecedent storage or rainstorms. Parameter $\hat{a}$ is negatively correlated with the recharge rate (Harman et al., 2009), the streamflow rate (Biswal and Nagesh Kumar, 2014), and initial groundwater table under unsaturated conditions (Rupp and Selker, 2006), while it has a slightly positive correlation under saturated conditions (Rupp and Selker, 2006). For parameter b, it slightly increases with a wet antecedent condition (Harman et al., 2009). However, drainage network theory indicates that b increases with peak flow while the downstream receives more subsurface flow contribution but decreases with peak flow as the downstream

receives less (Biswal and Nagesh Kumar, 2013). The inconsistent responses in $\hat{a}$ and b among theories indicate a complicated interaction between landscape structure and rainstorms during recession, implying that the recession mechanics in different regions need more exploration."

25: That "the recession coefficient, a, approximates the recession rate" is not a generally true statement.
Reply: Thank you. We removed the clause, "approximates the recession rate" [L27].

27-33: Which of these relationships were determined from theory and which were shown empirically?
Reply: Replied above.

51: Not yet clear at this point what "point-cloud" means. Please define.
Reply: We added the clause, "a collection of multiple recession curves" for clarification [L50].

51-54: I don't think it is correct to say that recession responses are dependent on "a" and "b". "a" and "b" are a convenient way for us to characterize recession curves. Real-world behavior does not depend on these artificial values.
Reply: The reviewer is right. We fully agree with this suggestion. We have revised the sentence as [L52-53]: "Fewer studies simultaneously addressed recession responses to landscape structure and distinct rainstorm events."

54-55: This statement appears to be very relevant to the authors' study. The authors should elaborate: Why do Biswal and Nagesh Kumar conclude that "b" may respond to peak flow differently depending on the structure of the drainage networks?
Reply: Thank you. We added a sentence in [L54-55]: "However, they did not specifically identify which landscape characteristics would predominantly influence the directional switch in the response of parameter b to rainfall."

80-83: It is not perfectly clear to me what exactly the flow-path length (L) is, which makes it harder for me to assess the physical significance of L/G. Is L the length of the hillslope, as in the distance from a drainage divide to a stream? How is it calculated for an entire catchment?
Reply: This comment and the following four are highly relevant with L/G ratio. Thus, we replied all comments and all corresponding modification in the revision. The flow path is defined as the hillslope grid point following the surface flow direction toward

channel. The revised sentences were: “The flow path is defined as the hillslope grid point following the surface flow direction toward the channel (see detail in Tetzlaff et al., 2009). Specifically, flow-path length (*L*) is the length of this path, flow-path height (*H*) is the height difference along this path, and *G* is the flow-path gradient [-]. Therefore, each grid cell can have its own *L*, *H* and *G*. The median value of these flow-path metrics in a watershed was calculated as the representative value for the catchment. Among them, the composite ratio of *L/G*, which represent the distance effect of flow-path under different gradient holds hydrologic significance as it can serve as a proxy for water residence time (McGuire et al., 2005; Tetzlaff et al., 2009). Therefore, these flow-path metrics are widely used as proxies for understanding the interaction between landscape and climate (Seybold et al., 2017). The detail definition and calculation of the flow-path associated variables are illustrated in Table S3 in supplementary.” in L80-88.

Is G = H/L? Is L/G, therefore, simply L/(H/L) = L^2/H? If so, what does L^2/H say about landscape structure that simply G (or 1/G = L/H) alone does not?

Reply: Replied above. The composite *L/G* ratio represents the distance effect of flow-path under different gradient. Both distance and gradient are highly relevant with water flow. In fact, the *H*, *L*, *G*, and *L/G* are significantly correlated to a (see Table 2). However, L/G is the best one to classify the catchment types (see Figure 6).

Given how much of the discussion on the results centers on L/G, it is important that its geomorphic/hydrologic/hydraulic significance be stated.

Reply: Replied.

How does a large value of L/G imply a “short-and-gentle” hillslope (as stated on line 364)? I understand that the “gentle” part comes from a low value of G leading to a high value of L/G. However, a “short” hillslope would have a lower L, which leads to lower value of L/G.

Reply: As reviewer mentioned, large *L/G* can be result from a large *L* or gentle *G*. However, in Taiwan, the median value of L among the catchments are quite small (see Table S2). Most median L values less than 300m indicate the length of flow paths in Taiwan is relatively short.

107: Actually, “b” is the slope in a plot of log(-dQ/dt) vs log(Q).

Reply: Thank you, we revised according to the suggestions [L112].

179: “This contrasting response coincided with a difference in drainage area and was relatively consistent across all catchments”. I don’t fully understand this sentence. What exactly was consistent across all catchments?

Reply: We rephrased in [L183-184]: “The contradictory responses observed in these three catchments can be attributed to variations in their landscape structure and rainstorm characteristics.”

192-193: Why make a distinction for catchments with drainage area larger than 800 km2?

Reply: We observed that when the drainage area larger than 800 km^2, the point-cloud-derived coefficients become similar to the third quantile of the coefficient distribution from individual segments [L197].

200-201: The Methods section should describe how each of these variables was calculated.

Reply: We added a new table, Table S3, which described the calculation methods for these variables. Additionally, we updated the numbering of the supplementary tables throughout the entire manuscript.

206-207: What might cause the opposite response of “b” to antecedent flow and peak flow? This seems to be an inconsistent result if both factors are related to storage at the beginning of the recession event. This topic should be revisited in Section 4.3.2.

Reply: We have followed the reviewer's suggestion and added content to section 4.3.2 in L325-328: “In our study, we observed an increase in recession nonlinearity with antecedent flows but a decrease with peak flow. This phenomenon can be attributed to the superimposition of recession events on antecedent flows, which amplifies the value of *b* (Jachens et al., 2020). The negative correlation between *b* and peak flow does not necessarily imply a consistent response across all catchments.”

228: I would rephrase this to say the point-cloud estimates are distinctly different from the estimates from the individual recessions. Both may have systematic biases since we don’t know the “true” values.

Reply: We used the reviewer’s sentence “Notably, the point-cloud estimates are distinctly different from the estimates from the individual recessions.”[L233]

228-230: I don’t think it is a given that a skewed distribution of flood peaks is the primary cause. Jachens et al. (2020) provide an example where the distribution of

peaks is not skewed and the point-cloud value of b is still less than those of the individual events.

Reply: We agree with the reviewer's comment. We rephrased as "The larger *a* and smaller *b* values derived from the point-cloud than from individual segments could be expected due to the influence of antecedent flow and superimposition of recession events (Jachens et al., 2020)." [L233-235]

235: Sharma and Biswal (2022) is missing from the References section.

Reply: Include in the reference [L476].

237-239: I don't think the authors' ranges of the recession coefficient can be compared directly to other studies because the units are not the same. Moreover, if the other studies did not apply the decorrelation method, the comparison may not be valid.

Reply: Thank you for your feedback. We removed the related sentences.

253: Roques et al. (2022) is missing from the References section.

Reply: Included in the reference section [L465].

281-284: I do not follow the authors' logic here. A high value of H does not necessarily lead to slower drainage. On the contrary, a steep hillslope implies a stronger hydraulic gradient and faster drainage.

Reply: We rephrased as [L280-282]: "Flow-path height, *H*, does not necessarily correspond to hydraulic gradients due to the geologic and soil setting in different regions (Karlsen et al., 2019). Our H, negatively correlated to the recession coefficient, likely indicated we have a deeper and longer groundwater flow system and thus drainage slowly."

SUGGESTED EDITS

Reply: We greatly appreciate the numerous editing suggestions provided by the reviewer, including the rephrasing of words and sentences.

50: Replace "treatments" with "analysis methods" and delete the parenthetical phrase that follows.

Reply: Rephrased as suggested [L50].

51: Delete "centrality of recession". It's a strange term and may cause confusion.

Reply: Removed [L50].

60: Replace “period typhoon invasions” with “periodic typhoons”.
Reply: Revised [L60].

64-65: Check for consistency in verb tense through paper. For example, “document” (present tense) and “discussed” (past tense) are used in the same sentence.
Reply: Thank you and checked [L65].

109: “unit” should be “units”.
Reply: Revised [L113].

111: Replace “manipulate” with “affect”.
Reply: Revised [L115].

150: Replace “was” with “is”.
Reply: Revised [L154].

154: The material that is covered beginning with “Secondly,” should be its own paragraph, as it is a distinct issue from data resolution. The new paragraph could begin with “An important concern in recession parameter estimation is the dependence between…”
Reply: Thanks and revised [L159].

155: Replace “blurs” with “confounds”.
Reply: Revised [L159].

188: I would replace “presents a vague pattern…”, with something like “shows no clear connection to large-scale landscape features on the island”.
Reply: Revised as suggested [L193].

190: Replace “fluctuated” with “differed”.
Reply: Revised [L195].

195: By “irrelative of drainage area”, do the authors mean “not correlated with drainage area"? The latter phrase would be clearer.
Reply: Revised [L200].

263: Replace “vague” with “weak”.

Reply: Revised [L262].

319: Replace “prevalently” with “prevalent”.
Reply: Revised [L318].

346: Replace “hydrological” with “hydraulic”.
Reply: Revised [L349].

355-359: I suggest deleting the entire part of this paragraph beginning with “Despite the power-law…” This paper is not about the impact of methodological choices.
Reply: Removed as suggested.

360: Replace “In our cases” with “In these catchments…”
Reply: Revised [L358].

360: Rearrange the sentence to read that the recession coefficient is moderately correlated to landscape structure while nonlinearity is only weakly correlated to landscape structure. Otherwise, it reads as if, for example, landscape structure is dependent on the recession coefficient. I would look for other places in the paper where the order should be reversed.
Reply: Thanks. We rephrased as suggested [L358-359].

360, 361: It would be clearer to always write “recession coefficient” and not simply “coefficient”.
Reply: Revised [L359, 361].

369: Delete “Further”. It is redundant to write both “further” and “also”.
Reply: Revised [L369].

369: Rewrite the first sentence. Rainfall amount effects the recession coefficient, it does not affect the “estimating” of it.
Reply: Revised [L368].

373: Replace “In sum” with “In summary”.
Reply: Revised [L372].

Reply to Reviewer 2 Comment

The reviewers' comments have been carefully addressed, the English substantially improved and the paper now conveys the results of the study and what it adds to the literature in a much clearer way.

Reply: We are grateful for the positive affirmation given by the reviewer. The suggestions provided in the past two rounds have significantly improved this manuscript.