Reply to Editor's Comment

Thank you for your corrections to the previous version of the manuscript. I spent quite some time going over your manuscript again and found that while your revision is an improvement, several issues still need to be clarified:

Reply: Thanks for your diligent review of our manuscript. We have made revisions to both the main manuscript and the supplementary material based on your feedback. We now proceed to respond to these comments point-by-point.

L/G: median L /median G or median L/G? There is a difference. In McGuire 2005 they use median L/median G. You say in Table S3 that you use median (L/G) – why? Explain what this means for your results. Especially as you are now using a different measure than previous studies.

Reply: Thank you for bringing up this issue. We have included additional sentences to emphasize the distinction between the approaches in L/G and our rationale [L89-92]:

> "Please be aware that we defined the median of l_{fp}/g_{fp} (L/G) in our study, differing from McGuire et al.'s (2005) previous study, which directly used the median l_{fp} divided by the median g_{fp}. In the hydrological context, l_{fp}/g_{fp} represents the residence time of each flow path and the median of l_{fp}/g_{fp} characterizes the flow paths within a catchment, while the median of l_{fp}/g_{fp} reflects catchment-wide residence time."

Also – you should state in the methods that you are using median values. Throughout the text it is not clear when you are talking about L or G or H if you are referring to the median or not. This needs to be clarified.

Reply: In order to distinguish whether the description refers to individual values or medians of flow path characteristics, we have employed two distinct labels. We have made revisions to certain sentences in [L84-89]:

> "Specifically, flow path length (l_{fp}) is the route length from a cell to channel cell, flow path height (h_{fp}) is the elevation difference between the specific cell to channel cell, and flow path gradient (g_{fp}) is calculated as flow path height divided by flow path length. Each cell possesses its own value of l_{fp}, h_{fp}, g_{fp}, and l_{fp}/g_{fp}. Since the velocity of gravity-driven flow is typically proportional to the gradient ($v = l_{fp}/T \sim h_{fp}/l_{fp}$), this implies that the time (T) is proportional to l_{fp}/g_{fp}: $T \sim l_{fp}^2/h_{fp} = l_{fp}/g_{fp}$. Consequently, l_{fp}/g_{fp} could serve as a potential proxy for residence time. Within a catchment, the medians of the l_{fp}, h_{fp}, and g_{fp} distributions (L, H, and G) served as representative flow path characteristics."

Why is L/G a good proxy for residence time? If you base this on Darcy's law it would be good to explain this better than the currently slightly confusing sentence: "Note that G can also be regarded as a surrogate of flow velocity (most equations used for estimating flow velocity needs gradient to represent the conversion from potential to kinetic energy). Therefore, the composite ratio, L/G [m], can be a proxy for residence time (McGuire et al., 2005; Tetzlaff et al., 2009) and as a means to

comprehend the interplay between landscape features and climate impacts on residence time (Seybold et al., 2017).” Instead I would suggest something similar to this (if this is indeed what you mean): As the velocity of gravity-driven flow is usually proportional to the gradient: v = L/T ~ H/L this results in time T being proportional to L/G: T~L^2/H=L/G. Therefore, L/G could be a potential proxy for residence time. In terms of a catchment this relates to the ratio of the medians of L and G.

Reply: We appreciated the editor provide the thoughtful explanation of L/G as the proxy of residence time. We rephrased the sentences in [L86-88]:

> “Since the velocity of gravity-driven flow is typically proportional to the gradient ($v = l_{fp}/T \sim h_{fp}/l_{fp}$), this implies that the time (T) is proportional to l_{fp}/q_{fp}: $T \sim l_{fp}^2/h_{fp} = l_{fp}/q_{fp}$. Consequently, l_{fp}/q_{fp} could serve as a potential proxy for residence time.”

What do you mean by composite ratio? What is the difference between composite ratio and ratio? Why is a simple ratio not enough? This needs to be explained.

Reply: Upon careful consideration, we have opted to directly remove the term "composite" in [L90], [L289] and [L302].

You are citing that Harman et al. 2009 found that heterogeneity between hillslopes increased with catchment area. However, they compare a single hillslope to a catchment of 10 ha and a catchment with a catchment area of 41 ha, so a maximum scale of not even 0.5 km². In your study, catchment areas only begin at 77 km². Does this relationship still hold at this very different spatial scale? This should be discussed.

Reply: We have added one sentence in [L266-270]:

> “The weak correlation between recession nonlinearity and those variables might be explained by: First is the scale effect. Some of our catchments are much larger than 500 km², which far exceeds the extent of rainstorms (usually less than 200 km²). In these large catchments, the limited extent of rainstorms would not bring about a comprehensive recession response in the outflow hydrograph (Huang et al., 2012). Second, the drainage area cannot reflect the unknown number of aquifers (Ajami et al., 2011), making it unclear whether a positive relationship exists between nonlinearity and drainage area in our study.”

Table 3 in the supplement – here the language can be simplified/clarified and there are also still some expressions that should be corrected:

- Definition of DD: fast not faster
- Water body coverage
- Forest coverage
- Agricultural land coverage

Reply: Thanks for the correction. We have enhanced the language in Table S3.

Please also see my comments to the supplementary material and within the pdf of your response.

Reply: Thank you for your thorough review of the supplementary material. Your advice has greatly

improved the supplement, and we have incorporated the revisions accordingly.

I am glad to see the major improvements in this manuscript over the course of the review and am hoping that we can resolve these issues with a last round of minor revisions. Given that there are still some issues with the language I have been in touch with the English copy-editing department of Copernicus and they will assist you with final improvements on this front. Unfortunately, even your revised abstract still needs work, as the sentences have the tendency to be convoluted and confusing. Looking forward to bringing this review process to a close and moving your manuscript forward towards publication!

Reply: We again revised the abstract [L10-22]:

> "Streamflow recession, shaped by hydrological processes, runoff dynamics, and catchment storage, is heavily influenced by landscape structure and rainstorm. However, our understanding of how recession relates to landscape structure and rainstorm remains inconsistent, with limited research examining their combined impact. This study examines the interplay between landscape structures and rainstorm characteristics in shaping recession responses, upon 291 sets of recession parameters obtained through the decorrelation process. The data originates from 19 subtropical mountainous rivers that display a wide spectrum of rainfall amounts. Key findings indicate that the recession coefficient (a) increases while the exponent (b) decreases with the L/G ratio (the median of ratios between flow-path length and gradient), suggesting that longer and gentler hillslopes facilitate flow accumulation and aquifer connectivity, ultimately reducing nonlinearity. Additionally, in large catchments, the exponent (b) rises with increasing rainfall due to greater landscape heterogeneity, whereas in small catchments, it declines with rainfall, likely indicating catchment is prone to saturated and thus reduced runoff heterogeneity. Our discovery underscores the necessity for further validation across diverse regions regarding how L/G and drainage area regulate recession responses to varying rainfall levels, given the pivotal role of assessing recession responses in understanding regional recession patterns within ungauged catchments, particularly within the context of climate change."

SPECIFIC COMMENTS

(in Response)

"*defined as.*" [L85]

Delete.

Reply: Revised as the suggestion.

"*Our variable H*" [L279]

Our variable H likely suggests... not clear. Do you mean: The fact that H is negatively correlated with the recession coefficient suggests that...? Also why the stress on it being your variable?

Reply: We rephrased this sentence based on the editor's comment [L283-285]: "The fact that *H* is

negatively correlated with the recession coefficient suggests that our groundwater flow paths possess greater depth and length, consequently leading to slower drainage rates."

"it does not necessarily correspond to hydraulic gradient due to the geologic and soil settings varying across regions" [L282]

I don't understand this. H/L is gradient, not H alone. Are you talking about the hydraulic gradients of GW level to stream? That can of course be different to the surface gradient to stream and depends on geology etc. Please clarify here what you mean.

Reply: We rephrased this sentence in [L285-288]: "While *H* is commonly believed to be positively correlated with the velocity of gravity-driven flow at a small spatial scale, the high heterogeneity in subsurface geology or soil properties at a larger spatial scale (Karlsen et al., 2019) implies that a large *H* does not necessarily lead to a large recession coefficient."

"While the equivalent composite ratio can result from either L or G," [L288]

This sentence is not clear. equivalent to what? not sure what results from either L or G is supposed to mean, either.

Reply: We rephrased this sentence in [L291-293]: "Potentially, the relationship between recession parameters and *L*/*G* has the chance to establish a further linkage between recession parameters and water residence time.".

"Explain why this can serve as a proxy for residence time and what you mean by composite ratio."

see comment in separate document

Reply: Replied in the general comment, seeing revised [L84-92].

"recession event flow" [L330]

event recession flows (at least for me it seems like event recession makes more sense than recession event - here it is not clear how exactly a recession event is defined.)

Reply: Revised as the suggestion [L334].

"responses to" [L10]

relationships with

Reply: Revised as the suggestion.

"rainstorm~~s~~" [L10]

characteristics

Reply: Revised as the suggestion.

(in the Supplementary Material)

Table S1: "un-decorrelated"

is this really a word? What about using "original values" or "values before decorrelation"?

Reply: We have replaced "un-decorrelated" with "original values." [Table S1]

"CTS and VTS denote constant and various time interval of sampling (Q, dQ/dt) pair, respectively."

this does not make sense. Do you mean variable?

Reply: We rephrased this sentence: "CTS and VTS represent constant and variable time intervals for sampling (Q, dQ/dt) pairs, respectively." [Table S1]

Table S2: footnote.

state if these are medians or means or what sort of summary statistics you are using here.

Reply: We rephrased this footnote: "Here, *H* is the median of flow-path heights, *L* is the median of flow-path lengths, *G* is the median of flow-path gradients, L/G is the median of ratios between flow-path length and gradient. *A* is the drainage area, *DD* is the drainage density, S_m is the gradient of main stem, *HI* is the hypsometric integral, ELO is the basin elongation, C_W, C_F, C_A is the coverage of water body, forest, and agricultural land, respectively." [Table S2]

Table S3:

this table still needs work language-wise.

Reply: We have enhanced the language in this table [Table S3].

Table S4:

remove the large space between the median and the max/min.

State in caption that max and min are given in brackets or provide separate headers for median, max and min

Reply: We removed the large space and also separated the headers of median, min, and max. [Table S4]

Reference

References

Reply: Revised as the suggestion.