

Response to reviewers

In this document, we address the comments and points raised by the reviewers, and we indicate where the changes included in the manuscript to fulfil the comments.

This is a much clearer paper than the original and the authors have answered most of my main questions (Reviewer #2 of the original paper). I have a few minor suggestions on this version.

Thank you for the time you devoted to reading this manuscript. We appreciate the kind comments of Reviewer #2 regarding the revised manuscript (1).

1) Figure 1 is a good addition. However, the top loop in 1A and the bottom loop in 1B both look flat. For illustration purposes it would look clearer if the long axes of those loops were more angled.

The Figure 1 was improved following the reviewer comments. See Figure 1 in the revised manuscript.

2) Figure 2. Would it be beneficial to plot the N concentrations on this plot as well (you could plot them on another panel above the main panel)?

We have followed the reviewer suggesting, including the N concentration in Figure 3. Please see Figure 3.

3) Figure 4. These visualisations are useful but may be better to add those schematic loops to Fig. 6 as that is where the data are plotted and there is ample space in one or both of the parts of Fig. 6 to add those schematics.

Following the reviewer suggestions, the Figures 4 and 6 were merged,

Finally, I suggest moving the final paragraph of the Discussion (L398-404) into the Conclusion and adding it to / merging it with the last paragraph (L413-416) as both deal with overlapping broader implications.

The paragraph was moved to the conclusion section in the revised manuscript. L. 447-450.

Reviewer 2

Dear Reviewer,

Thank you for the time you devoted to reading this manuscript and for your helpful comments. We took your remarks and suggestions into account to improve our manuscript. In addition, the manuscript has been again checked by a native English speaker.

The reviewer points out the lack of event definition and identification and the differences in the statistics used as the weakest aspects of the work. These aspects have been addressed in the corrected version of the work. L.

Specific comments:

Line 17: Not clear what is meant here by the overall dynamics of hysteresis. Please clarify.

Sorry. It was changed in the revised manuscript. We want to say hysteresis direction.

Line 17, 198: The concept of dynamics of hysteresis (dR) is different from the hysteresis direction stated in the Method section. Please use only one term throughout the manuscript.

It was corrected in the revised manuscript. We used hysteresis direction throughout the manuscript.

Line 18: Element is ambiguous, compound is a better term. Thanks, the term has been changed in the revised manuscript. L. 18.

Lines 20-23: The meaning behind each of the mentioned characteristics (e.g., difference between peak discharge and event magnitude) and the direction of change produced by different event characteristics is not clear at this point. Please use more comprehensive terms.

Thanks. It was clarified in the revised manuscript. L. 20-24.

Line 24: It is not clear what is meant by the magnitude of the event here. Is it the volume or the peak discharge. Please either explain the meaning of the characteristics used in the abstract directly in the abstract or use only unambiguous terms.

The magnitude is $(Q_{max}-Q_b)/Q_b$. It was clarified in the manuscript. L. 22.

Figure 1: Please also label dilation and enrichment pattern. Consider highlighting the line showing the width by a different color. Please clarify in the caption if there is a difference between “rising slope” and “rising limb”. If not, use the same term.

The Figure 1 was improved following your comments of both reviewers. Pg. 2

Line 75, 204, 383: do not use the term “significant” if it is not associated with the significance testing.

In agreement. The term has been modified in the revised manuscript following the indications of the reviewer.

Line 106: Please indicate how close the station is.

This information was added in the revised manuscript. L.115-116

Line 110: It is not clear what is provided in the brackets? The range of elevation? Usually, the range is provided as min-max and not the other way around.

Effectively, the information contained in parentheses indicates the elevation range. Sorry for the mistake, in the revised manuscript it has been provided as min-max. L. 101.

Figure 2. Please modify the colors of the land uses, it is difficult to distinguish. Consider

simplifying the land use types. Please indicate the location of the three meteorological stations mentioned in the text,

Figure 2 was improved following the reviewer indications. Pg 5

Lines 133-134: How was the start of the rainfall event defined? To compute the increase relative to the start of the event, the start has to be defined first. Please clarify.

The definition of rainfall event was included in the revise manuscript. L. 133-139.

Lines 139-141: I do not think this information is used in the analysis. Please delete all unnecessary information or clarify how it was used.

All right! The information was deleted, and the paragraph reformulated. L. 144-146

Lines 149-150: This definition of rainfall start does not agree with autosampler operation mode described in Line 133-134. Please also clarify what does “usually exceeds 5 mm” mean? Is there no fixed threshold?

This information was clarified in the revised manuscript. L. 153-159.

Line 153: What is a “perceptible increase”? Is there a clear threshold for that? Please clarify.

This information was clarified in the revised manuscript. L. 153-159.

Line 154: It is not clear if events finish when they reach exactly the same initial baseflow conditions or not. Please clarify. Moreover, given an unclear definition for the event start it is also not clear how exactly the termination of the previous event is defined when it is followed immediately by the next event. Please clarify this too.

This information was clarified in the revised manuscript. L. 153-159.

Line 162: term “water yield” is rather ambiguous, consider using “total runoff volume” instead.

Ok. It was modified following the reviewer indications in the revised manuscript. L. 163; table 1, figure 6.

Lines 164-166 Please clarify how rising and falling limbs are defined. Homogenize usage of Rd and RD.

We clarified how rising and falling limb were defined. L. 168-170. We also included in the Figure 3

Sorry for the mistake. It was corrected in the text of the manuscript and in the table.

Figure 3. Please also display how the slope of the falling limb is defined in this Figure. It would be helpful if all characteristics from Table 1 are displayed in this Figure. Please also make sure that the acronyms in the figure and in the table are identical.

The Figure 3 was improved following the suggestions of both reviewers

Lines 174-175: It is not clear why the number of events has reduced from 156 to 102. Please clarify.

The way in which the events were selected is indicated in the revised manuscript. L. 182-185.

Line 178: Please clarify how close it has to be.

The information was added. L. 183

Table 1: All event characteristics have to be explained in the Table or in the text (e.g., how the initial phase of the falling limb identified?). Please use identical terms for event characteristics in the text and in the table (e.g., event magnitude relative to baseflow is listed here as magnitude of event and can be easily confused with peak discharge).

All right! All event characteristics have been explained in the text.

Line 215: previously the term “direction” was used instead of “rotation”. Please keep homogenous terminology throughout the manuscript.

Sorry. We used direction in the revised manuscript.

Lines 217-218: What does it mean? Were these events treated differently? Please clarify.

No, they weren't. It was deleted.

Line 223: which examined characteristics can be considered biogeochemical? Please clarify.

We are taking about nitrogen concentrations. The information was added in the new version of the manuscript. L. 225

Lines 225-227: From this description, it is not clear what is the additional value of the redundancy analysis compared to correlation. Please clarify.

This section was modified; we hope it was improved. L. 226-235.

Line 230-235: a boxplot figure displaying described variability among events will be useful here.

Following the reviewer comments the new figure 4 was added.

Figure 5: I think this figure is more comprehensive than figure 4 and they can be merged together. The date on the d panel is not clear. Please revise.

The data of d panel was corrected.

Following the indications of the other reviewer, the figure 4 was merged with Figure 6

Line 246: Based on the units it should be volume instead of magnitude. It is not clear which data is not shown here. In general, all relevant data should be provided. Moreover, it is not clear what is the general length of recorded rainfall events (min and max).

Sorry for the mistake; it was corrected. Magnitude was replaced by volume. L. 255

It was changed and the min and max values were added. L. 256-257

Line 247: volume instead of magnitude?

You are alright; it is volume. It was changed. L. 257.

Line 251-252: I do not really see it in figure 5. Autumn events are only displayed for NO₃ and it is not really much different from winter in terms of concentrations. Moreover, be cautious in drawing such general conclusions from singular cherry-picked examples.

Alright! Now it can be seen in the new Figure 4.

Section 3.2. Please add percentage instead of absolute number of events.

Ok, it was added in the revised manuscript. L. 271, 272.

Figure 6: Please, add labels to the subplots. I see no horizontal dotted lines in this figure that are mentioned in the caption. Please clarify.

The Figure was improved, now it can be possible to see the horizontal dotted lines. The caption was also completed. L. 289-292

Section 3.3. Please use full names when referring to different event characteristics in the text to make it more readily understandable for the readers.

Ok. The full names were used in the new version of the manuscript. L. 301-325.

Line 305: it is not clear which variables exactly are meant here by “rainfall-runoff magnitude”. Please clarify

Ok; it was completed. L. 323-324.

Line 330-331: This conclusion is not straightforward. Please elaborate on that.

Line 337-338: This is not a part of the manuscript anymore, you cannot not reference the results that are not presented in the manuscript. Please revise.

Ok. The sentence was reformulated in the revised manuscript. L. 350-351

Line 341-344: This reasoning is not convincing. The authors attribute the anticlockwise hysteresis patterns to different pathways (subsurface and groundwater), however low nitrate concentration in subsurface flow at the beginning of the runoff event could also be linked to the runoff generation zones that are closer to the stream, and therefore with the spatial distribution of sources. Please justify your reasoning on why this is not the case for the study area.

Ok. We have checked the statement and modified it in order to clarify our point. L. 364-369.

Line 356: event water contribution was not quantified in this study. Please revise.

Ok. The paragraph was reformulated. L. 355-360.

Line 359: What is meant here by direct rainfall? Please clarify.

It was clarified in the revised manuscript. L. 383-385

Line 376: the meaning of the information provided in the brackets is not clear. Please elaborate. Please also clarify how the distance of sources is related to event magnitude. Please notice that previously the term event magnitude was used in a different meaning (relative increase of streamflow compared to baseflow, while now it refers to precipitation volume). Please homogenize the terms throughout the manuscript.

The paragraph has been reformulated in order to clarify our point. L. 401-402.

Line 388: which rainfall characteristic is meant here? What is meant here by event magnitude? Please clarify.

It was clarified. L. 404.

Line 395: This statement needs a reference (e.g., Heathwayte and Bieroza 2021 might be suitable here) and a further explanation on how biogeochemical processes are influencing hysteresis patterns of nitrate.

Thanks. The reference and the explanation were added. L. 424-428.

Line 397: This statement also needs a reference. How does the buildup of nitrate affect the biogeochemical processes involved

Ok. The paragraph was modified in order to clarify the statement. L. 431- 434.

Line 402-403: This sentence has to be revised, it does not make sense.

The sentence was checked and added to the conclusion section following the suggestion of the other reviewer. L. 447-450.

Line 403-404: This is rather vague. What additional event-based studies can provide that was not observed here? Please clarify

Your are right. It was deleted.

Line 412: Here I would expect a summary of main mechanisms that were identified by the dual analysis.

It was added. L. 439-440.

Editorial comments:

Line 18: dominated by enrichment

Line 33: freshwater bodies

Line 36: commonly at biweekly or monthly resolution

Line 43: nutrient concentration

Line 48: can be classified

Line 51: distant to the stream
Line 53: omit etc
Line 56: nitrogen species
Line 64: rainfall and runoff event characteristics
Line 78: through
Line 80: changes in the quality of freshwater resources
Line 87: C-Q relationships
Line 100: indicating relatively low nitrogen inputs in the Corbeira catchment compared to...
Line 161: determined according to Wischmeier and Smith (1958)
Line 180: evaluated visually
Figure 4: reduce white space
Line 233: selected events
Line 247: several events
Line 321: the Corbeira
Line 325: increased nitrogen concentration during individual events
Line 338: contribution from the subsurface flow
Line 348: that have recently received fertilizers
Line 383: on hysteresis patterns?
Line 393: particulate material

Sorry for the mistakes. All editorial comments were taken into account and corrected.

References:

Heathwaite, A. L., & Bieroza, M. (2021). Fingerprinting hydrological and biogeochemical drivers of freshwater quality. *Hydrological Processes*, 35(1), e13973. <https://doi.org/10.1002/hyp.13973>

Thanks. The reference was added in the revised manuscript.