A global algorithm for identifying changing streamflow regimes: Application to Canadian natural streams (1966-2010)

Point-to-point Reply to the Editor's and Reviewers' comments

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I. Reply to the comment made by the Editor

1. *thanks for being patient. The two reviewers and I find the manuscript much improved and note only minor issues to be resolved now. Please clarify them, in particular the notation issues raised by R1 and please really make an effort to improve the language as noted by R2. Both, clarity and concise writing without unnecessary words will ultimately improve the impact. I am looking forward to the revised version of your manuscript.*

Response: Many thanks for handling our manuscript. We are very pleased that our efforts during the discussion and revision of the paper are recognized by the editor and the two anonymous reviewers. We carefully revised the manuscript to avoid grammatical issues and to have a concise and clear contribution. We are grateful for the comments received from both reviewers and can clearly see the positive impacts of these comments on our final product. We highly appreciate their time, and yours indeed, put selflessly on our paper; and we very much look forward to having this paper out soon.

II. Reply to comments received from Anonymous Reviewer 1

1. *The authors are to be congratulated on their revision, which has greatly improved the paper. I was very pleased to see that their analyses now include ecozones, and the paper is much stronger for it. The figures are very attractive.*

Response: We greatly acknowledge the time and effort put by Anonymous Reviewer 1 (AR1) on further evaluation of our manuscript. We are thankful for the constructive comments provided by AR1 and are happy that our revised manuscript was found improved and visually appealing by AR1.

2. *Unfortunately, the results are undermined by the writing. I am providing some suggestions, but the paper would benefit from a thorough editing to tighten the writing, and to remove the many grammatical errors, poor word choices, and excess verbiage.*

Response: Many thanks for your comment. We do acknowledge your concern. We have rigorously edited our paper to have a concise and clear manuscript. We implemented your suggestion throughout the paper. We believe that this comment made us to have a better manuscript now.

General comments

3. *The paper is riddled with cliches:*
   "to name a few"
   "We recognize that"
   "Considering the available data"

"Looking however at the drainage basins"
"First and foremost"
"sets the scene"

These are unnecessary, and colloquial. Please delete them.

Response: Many thanks for your comment. We edited the paper and revised the word choice as AR1 suggested.

4. *The terms "higher", and "lower", unless you are talking about elevations, should be "greater" or "larger" and "smaller"*
Response: Many thanks for your comment. This is taken care of now throughout the manuscript.
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Detailed comments

5. *Line 27*
"early settlements"
These are things, not points in time. I think you mean "the times of the first human settlements"
Response: Many thanks for your comment. We revised the sentence.

6. *L 29*
"reveal"
This word is used far too often, and incorrectly.
I think that "indicate" is what you mean.
Response: Many thanks for your comment. This is taken care of throughout the manuscript.

7. *L 30*
"some"
I think that "others" is more useful
Response: Done.

8. *L 50*
"it is"
Disagreement in number. Should be "are"
Response: Done.

9. *L 60*
"relativity"

This is rather confusing in a scientific paper, particularly when you refer to "time and space"!
It's also a bit vague.
What is relative to what?
Response: Many thanks for your comment. It is substituted with "subjectivity".

10. *L 77*
"some of which with"

Replace "with" by "have"
Response: Done.

11. "dynamics"
I'm not sure what this means
Response: the dynamic is now replaced by "trends"

12. *L 78*
"with characteristics"
Should be
"of characteristics"
Response: Done.

13. *L 81*
"makes"
I think that "creates" would be better.
Response: Agreed**.** Done.

14. *L 126*
"in a way"
Would advise inserting "such" after "in"
Response: Done.

15. *L 142, eq. 2A*
It would be nice to have a verbal description of the objective function. Does it have a reference?
Response: Many thanks for your comment. The description and the reference are added. Please see **line 132.**

16. *L 177*
I was confused in this section.
The meaning of the baseline isn't really explained very well.
Response: Many thanks for your comment. The explanation is added to the **line 166** in the revised manuscript.

17. *L 190*
"sum of memberships in each timeframe is one"
I suggest that you use "1" as "one" could be part of a phrase, like
"one of the …."
Response: Done.

18. *L 191*
"one or more clusters".
This is confusing. Shouldn't it be "other clusters"?

Response: You are right**.** Done.

19. *L 218*
    "transparency"
    How it this method more transparent than others?
    Response: We revised the sentence to clarify better what we mean. Please see **line 212** in the revised manuscript.

20. *L 219*
    "is tied up with attribution"
    Could be shortened to "attributed"
    Response: Done.

21. *L 221*
    "Black and red lines"
    Please add a leading "The"
    Response: Done.

22. *"expected annual hydrographs"*
    What are these – how are the values expected? Please explain.
    Response: Clarified in the text. Please see revised version **line 215**.

23. *L 236, 3 Case study and data*
    A lot of the following information could be summarised in a table.
    Response: This can be true and we used tables and other elements in the Supplement. However, we believe our paper should have a concise descriptive overview on Canadian drainage basins and ecozones particularly for non-Canadian readers. We keep the description but made an effort to shorten and restructure to improve the flow.

24. *L 237*
    "With the total catchment area equivalent to"
    Replace with "With a total catchment area "
    Response: Done.

    "roll coast to coast to coast and during their journey"
    Unnecessary, please delete
    Response: Done.

25. *L 245*
    "largest water bodies"
    Not a very good description. Perhaps you could say some of the largest lakes other than the Great Lakes.
    Response: Agreed. It is now revised.

26. *L 246*
    "Mackenzie"
    Should be preceded by "The"
    Response: Done.

27. *L 250*

"While drainage basins"
"While" is usually used to mean "at the same time as".
I would suggest using "Although"
Response: Done.

"in which the streamflow is traced from headwaters to oceans"
Unnecessary, please delete
Response: Done.

28. *L 254*

"patch of terrestrial land"
Unless we are talking about other planets, "land" implies "terrestrial"
Suggest replacement with
"terrestrial region"
Response: Done.

"distinc"
Misspelled – should be "distinct"
Response: Done.

29. *L 256*

"only major Canadian region outside the Rockies"
Really? Isn't this contradicted by the existence of every other ecozone?
Response: Many thanks for your comment. This was a typo. We meant the only major Canadian mountainous region other than the Rockies. It is now corrected.

30. *L 340*

"glacial-fed or lake-dominated streams"
This would be a good place to add a statement on the effect of storage to the slow responses of these streams.
Response: Many thanks for your comment. A description is added to explain how storage of lakes lead to slow response of the streams. Please see **line 329** in the revised manuscript.

31. *L 345*

"other processes such as fill and spill"
Agreed. However the process should probably be explained for readers not familiar with it.
Response: A short description of fill and spill is added. Please see **line 335** in the revised manuscript.

32. *L 381*

"belongingness to"
This isn't the right word in this context, as it refers to an emotional state. I would use "member of"
Response: Done.

33. *L 386*

"less"
Should be "fewer"
Response: Done.

34. *L 413*

"vibrant"

Not a good word to use as its meaning is unclear in this context.

Response: Many thanks for your comment. It is now substituted by "varied"

35. *L 434*

"percentage"

Looks like the fraction to me

Response: Many thanks for your comment. It is now substituted by the fraction.

36. *L 436*

"second cell from right" – I would say "left hand cell"

"first cell from the right" – I would say "right hand cell"

Response: Done.

37. *L 450 Figure 9*

I couldn't tell what the sizes of the squares mean – are they a function of some value?

If not, it would make the colour differences more visible if the squares were the same size.

Response: Many thanks for your comment. Yes, it is a function of values of R^2. The smaller R^2 corresponds to the smaller the size of the square. This is for better visibility of the larger values and avoiding a busy figure.

38. *L 479*

"choosing"

I would say "selecting"

Response: Done.

39. *L 485*

"due to the insufficiency"

Of what?

Response: due to the insufficiency in number of data points. It is now corrected in the text.

40. *L 494*

"not significant changes"

I may have missed this – where was the significance test?

Response: The word significant was misleading. It is now revised.

41. *L 496*

Figure 10

What are Dimension 1 and 2? I know that they are referred to in line 489, but it would be nice to see an explanation.

Response: A short description added. Please see **line 483** in the revised manuscript.

42. *L 519 - 5.2 Validation in unseen streams*

I think that "unseen" is a bit confusing. Perhaps you could refer to the out of sample streams.
Response: Done. It is now substituted by the out of sample streams.

43. *L 523*
"because the majority of annual streamflow volume is contributed from mountainous headwaters outside of Prairies"
This is true of the large rivers, as well the smaller streams you examine in the extreme western portion of the ecozone (such as the Waterton River near Waterton Park and Belly River near Mountain View), however it is not true of the other prairie streams that you feature.
Response: Many thanks for your comment. You are totally right. Other factors are also added to include other prairie streams. Please see the **lines 521-525** in the revised manuscript.

44. *"fact that large proportion of the land does not contribute into the streamflow"*
This needs a citation. Also, it is not true for some basins in the region, and is not always true for the remainder, as the contributing fractions of these basins vary over time.
Response: Many thanks for your comment. The references are added. As you said, it may not be true for all basins in the Prairies, so the sentence is revised. Please see the **line 524** in the revised manuscript**.**

45. *Another issue is that many Prairie streams only have seasonal records, which can mess up analyses requiring entire years of records.*
Response: Many thanks for your comment. We only considered streams with continuous data records for the analyses.

46. *L 529*
"Waterton River near Waterton Park (S69) and Belly River near Mountain View (S70)"
Since you are referencing the streams in Figure 12 by their WSC gauge IDs, you should also list the IDs here.
Response: Many thanks for your comment. We also added the gauge IDs to the text.

47. *L 532*
"are sorted from the east to west"
I would use "ordered" rather than "sorted".
Response: Done.

48. *L 545*
"a fully algorithmic framework"
I don't understand what this term means
Response: It is now revised.

49. *Finally, I was disappointed to see that all of the analyses were done using a closed-source language. This is particularly troubling because the analyses include significance tests, where the value of a calculated statistic is compared to a fixed threshold (i.e. $p = 0.05$), resulting in acceptance or rejection of a null hypothesis. A small error in the statistic can therefore result in a very large effect, and we can have no understanding of how the statistic was calculated. I would encourage the authors to use open-source languages in the future for their analyses.*

Response: Many thanks for your comment. Totally agreed. We surely consider doing the analyses in an open-source language in the future.

III. Reply to comments received from Anonymous Reviewer 2

1. *The paper presented by Zaerpour and colleagues has much improved and I second the author's effort to increase the clarity of their Work while making the text more compact at the same time. Overall, I very much appreciate the effort of the authors to put their methodological development into context. I also welcome that the case study now revolves around the analysis of climatologically distinct ecozones in Canada. With these significant additions, I find that the paper is almost ready for publication in HESS.*

   Response: We greatly acknowledge the time and effort Anonymous Reviewer 2 (AR2) put on evaluating our revised manuscript. We are very happy that AR2 found our revisions effective!

   Nonetheless, a few comments remain:

2. *P5, L 523: It is not clear what X and Y are. I suspect X = mean and Y = sd but making this explicit would help.*
   Response: Many thanks for your comments. You are totally right. X and Y are the expected mean and variance of 15 indicators. We added an explanation to **line 421**.

3. *Notation of Equation 2a and related text: I suggest to use a capital C for denoting the cluster number to indicate that this is not an index. Similarly: consider to replace the index k with small c, which might increase the readability.*
   Response: Many thanks for your comment. Totally agreed. We revised notations in Eq. 2a and elsewhere, accordingly. It reads better now.

4. *Mix of Kendall-statistics and R2 for the attribution work: I still find it unconventional to first rely on a rank-statistic for identifying significance and then use a conventional R2 for quantifying the strength of the association. To me it would be more natural to either (a) pair the Kendall statistics with the (squared) rank correlation coefficient or (b) rely on the (squared) Pearson correlation coefficient alongside a standard test for significance for this metric. Note that rank-correlations (e.g. Spearman's coefficient) should indicate even higher degrees of association in case the data have a non-linear relation. Note, however, that I am confident that the choices made here will not have a significant impact on the conclusions.*

   Response: Many thanks for your comment. We used R^2 to determine how much variability in the degree of membership can be described by the variability of a given streamflow characteristic. However, to address your concern we repeated the calculation using squared Kendall tau measure which is rank-based measure of dependence. As you can see in the following Figure the result does not change significantly. In some cases, however, the degree of association using Kendall tau measure increase compared to the R^2 as you mentioned, which means we see a stronger link. We added the Fig. 1 shown below (Fig. S9 in the supplement) and the discussion related to this analysis on the sensitivity of the attribution results to the choice of association measure in **lines 509-514** to the discussion Section.

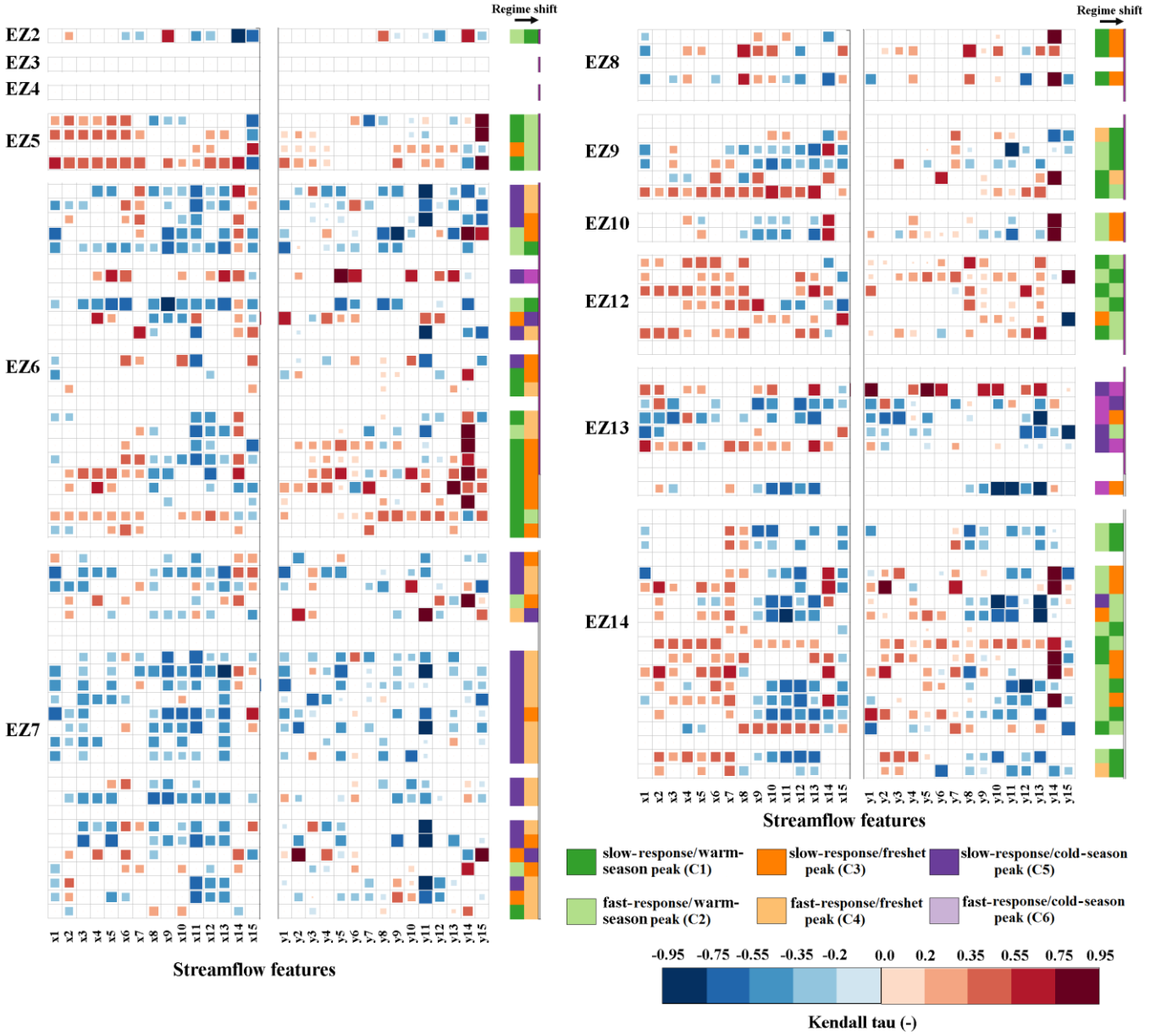

Figure 1. Dominant regime shifts across 105 RHBN streams in Canada attributed to the first and second moments of the 15 IHAs considered. Shades of red and blue show the values of squared Kendall's tau between changes in streamflow features and degrees of membership. The dominant regime shift at each stream is identified by the color scheme described in the legend. Streams are grouped in ecozones and ordered from low (top) to the high (bottom) elevations.

5. *Fig. 1: indicating what NSF_1 or NSF_2 are in the caption would make it easier to understand the concepts.*
Response: Many thanks for your comments. We think you meant Fig.3. If so and for the sake of clarification, an explanation is added to the caption. Please see **line 200**.