

Reviewer 2:

The authors present a unique dataset of seasonal stream chemistry of 10 catchments spanning a latitudinal and permafrost gradient in the Yukon. The objectives were to unravel the drivers behind the seasonality of major ion and DOC concentrations in catchments, while accounting for stream discharge variability. The manuscript is generally well written and organized, however, the presentation of the results makes it difficult to link the findings to the conclusions and conceptual models. Some additional analysis and figure adjustments may help to clarify this point. It is worth noting that multi-year datasets such as this are challenging to produce and are a rare occurrence in the North. This is a valuable contribution to the literature, but some improvements could be made as suggested below.

We very much appreciate your feedback.

General:

1. I was surprised about the lack of time series data presented. I think it would be worth presenting it, at least in supplemental data. It was difficult to grasp exactly when samples were taken over which years for what catchments.

We have added a figure in the SI (Figure S1) which shows when samples were taken. We also reference this figure in text in section 3.1.

“Detailed time series information on when samples were collected, are represented in Figure S1.”

2. I found it difficult to interpret the figures in results, even with the description in the results section. I think there is a missed opportunity to better link your results to your conceptual model. Can some of the key drivers you mention be included in these figures through colour, annotation, or organization? Some specific suggestions are below.

We have edited figure 6 so sites are color coded by permafrost extent and topographical gradients as well. In addition, we have made significant edits to the results and methods section to improve clarity on how to interpret results.

3. While the conceptual model intuitively makes sense, and the interpretation of the results seem valid, there is still a bit of a tenuous connection between the drivers of seasonality. 10 catchments is a relatively high number, so could there be some additional univariate or multivariate statistics be done to more firmly link the drivers to the results? As a very simple example, correlation between average catchment slope and DOC variability?

Although we have a limited number of sites, we have added further statistical tests to determine the influence of catchment characteristics on the seasonality and the average of solute concentrations. The tests are discussed in detail in the newly added sections 2.6 and section 3.3. Specifically, we use correlations between mean catchment slope vs sDOY range for all solutes. Since permafrost extent can only be estimated as a categorical variable, we opted to use ANOVA and Tukey tests to assess significant differences in sDOY range. Similarly, we use ANOVA and Tukey tests to assess significant differences in median concentrations of solutes amongst permafrost extents, and we use Pearson's correlation to assess the influence of mean catchment slope on average solute concentrations. The discussion now also incorporates these findings.

Section 2.2: This section could be removed and the information be combined with the previous section since there is already detailed descriptions of each of the catchments in 2.1.

Section 2.2 is now incorporated into section 2.1.

Line 188: Can you be more specific about timing of the sampling? Was this just once in May/June and a second July/August? How are you defining spring and summer?

Timing varied across sites. The definition of spring would also largely depend on the site in the context of this line. We have reworded to clarify that samples were generally taken whenever the streams were not ice covered. The line now reads:

"We collected grab samples for major ions and dissolved organic carbon (DOC) across flow states and open water seasons at all sites over multiple years."

Line 204: Was this measured in all catchments continuously throughout the entire study period? Was this data used in the analysis or did you just use the YSI data? If continuous data for this exists for each catchment, I think it would be worth presenting.

Although we have continuous SpC data at some sites for certain years. The data has too many gaps and is missing from some sites making it difficult to incorporate into the manuscript. SpC samples were taken from spot measurements from a handheld YSI probe. The section referencing continuous SpC collection has now been omitted, as it was never referenced in text.

Figure 3: Can the data be colour coded to permafrost extent or other key catchment characteristic? It might help tease out if there are other relationships going on and support the conceptual model.

Yes. Two additional figures were included in the supplemental information. These figures are identical to figure 3 but the colors represent catchment permafrost extent and topographical gradients. The caption for figure 3 now reads:

“Figure 3. Solute concentrations plotted against flow for all sites. Winter samples were lumped in with spring. Analogous figures where samples are color coded by permafrost extent and topographical gradients instead of site names are available in the SI (Figure S2; Figure S3).”

Figure 4: Similarly, could you put these in order from lowest to highest permafrost coverage or catchment slope?

As permafrost extent cannot be represented as a percentage (due to high uncertainty in permafrost coverage products), we cannot order by permafrost coverage. However, we do references in text that all TWO sites have greater than or equal to permafrost extent when compared to WCRB sites (with the exception of Km 44).

Figure 5: Can you include annotations or an additional example box that explains how to interpret these curves? Perhaps it could just be added to the caption as well.

We have changed the caption for additional clarity. We now clarify that the plots represent the sDOY value in reference to equation 1 and 2. We now clarify how the value of the term changes depending on the DOY. Initially the caption was:

“Figure 5. sDOY from GAMs for all solutes and sites where the sDOY was significant (p -value < 0.05) and 321 mean SE was less than 0.4.”

Now the caption reads:

“Figure 5. Partial effect plot for sDOY term from GAMs for all solutes and sites where the sDOY was significant (p -value < 0.05) and mean SE was less than 0.15. The plots represent how the value of the sDOY term in equation 1 and 2 changes depending on the day of year a sample was taken. Larger sDOY shift over time represents greater relative change in solute concentrations driven by processes other than seasonal discharge. The sDOY value is logged, thus a shift of 1 (i.e. Mg for Km 104) would result in a 10x increase or decrease of solute concentrations if discharge is constant.”

464-467: Right now, your figures do not demonstrate this readily.

We believe that figures 6 and 7 (now updated), along with the addition of correlation and ANOVA tests support our claims.

Figures 7 and 8: Remove the description from the figure itself. This should just go into the figure caption.

The description from figures 7 and 8 (now 8 and 9) were moved from the figure to the caption itself.