

Author response to Anonymous Referee #2 comments: High Temporal and Spatial Nitrate Variability on an Alaskan Hillslope Dominated by Alder Shrubs.

All author responses appear in grey italics below specific comments from Anonymous Referee #2.

General comments

This study presents a comprehensive dataset which illustrates how substrate source (alder litter) and spatial connectivity in a sloping permafrost landscape may be larger control on NO_3^- presence in uplands than soil moisture content, how increased NO_3^- related to N fixer presence may be mobile in the landscape, and how redox conditions related to soil moisture and topography impacts the spatial extent of this mobility. This is a valuable contribution which underlines the importance of considering topography and N fixers as plant functional type in predictions of future plant N availability and potential N_2O emissions.

However, this is a complicated dataset, and the study could benefit from a more coherent storyline, where the different datasets are presented not only in sequence, but are used together to tell a common story and the reader understands why the methods were chosen. This is done nicely in the abstract, but lacks in the discussion, where the $\delta^{18}\text{O}$ results and the $\delta^{15}\text{N}$ and NO_3^- concentration results are, I suspect, not intended to be two separate stories, but they appear as such at the moment.

The authors thank Anonymous Referee #2 for acknowledging the contribution of this study and for their constructive feedback. The authors have made note of the 'two separate stories' comment and will consider moving the isotopic data from the main text to the Supplement since it may distract from the main findings of our study. If we decide to keep the isotopic work in the main text, the authors will thoroughly rework the discussion to ensure the storyline is cohesive.

A few more specific section comments:

Introduction: The language could use an overhaul, mainly a condensation of the text, where some points are repeated and some sentences/sections come out of context (see specific comments below).

The authors thank Anonymous Referee #2 for their insights and will spend time rewording the introduction to condense the text and streamline our message.

Materials and methods: The sample design is very comprehensive and complicated and as such benefits from a detailed description. However, the information could be more closely related to Figure 1b and 1c for clarity and condensed. The description of isotopic calculations is clear and useful. There is a lack of a quantitative estimate of precipitation (now currently addressed simply as "Precipitation events") from e.g. a micrometeorological station, as the precipitation downslope movement of NO_3^- is such a central part of the results.

The authors thank Anonymous Referee #2 for their insights and agree that the text should be linked more closely to Figure 1b and c for a visual reference to our design and will modify the M&M text accordingly. The authors also acknowledge that the precipitation events are lacking detail as these are based on in-person observations in the field and we unfortunately did not have the equipment to quantify precipitation adequately. However, not including these qualitative in-field observations of precipitation that correlate strongly to observed $\text{NO}_3\text{-N}$ transportation downslope along our transects, would be a disservice to the audience of this manuscript. So although we are left with qualitative rather than quantitative information for precipitation events, we choose to leave this information in the text.

Discussion: The storyline of the discussion is not clear and appears more as a list of results related to literature

than a use of results to illuminate your research questions. As an example, the discussion of $\delta^{18}\text{O}$ related to precipitation events (line 328-339) comes a bit disconnected from the NO_3^- -story, but I suspect there is a point related to N transport, which needs to be clarified. The discussion needs to be restructured and condensed to tell the study story based on the results.

The authors thank Anonymous Referee #2 for their insights and agree that the discussion could be strengthened to better emphasize the connections between our geochemical observations and N transport. The authors will rewrite this section for improved clarity with a streamlined storyline.

Because of the large revisions needed in the communications of the results, I recommend that the manuscript can be reconsidered after major revisions.

The authors thank Anonymous Referee #2 for their suggestion and will work to improve the quality of the writing to streamline our findings and strengthen emphasis on our outcomes.

Specific comments with line numbering

Line 35-37: Which links and why is it important? Give one or two examples for a more engaging story.

The authors thank Anonymous Referee #2 for this suggestion and will add examples of the linkages between C and N in the text, including “both C and N are of critical biological importance in Arctic coastal waters and changing fluxes from Arctic runoff are influencing primary productivity (McClelland et al., 2007), C to N ratios in Arctic tundra determine response of plant productivity to climate change (Weintraub et al., 2003), and that N likely exerts control on whether C is biogeochemically transformed in reactive catchments, which directly influences carbon-climate feedbacks (Koch et al., 2013).”.

Line 51-56: This second half of the paragraph seems a bit out of place, because the text introduces alder effects on soil chemistry above and continues below. Consider moving it and even skipping line 51-52 or replacing the sentence in line 39-40 as they say much the same.

The authors thank Anonymous Referee #2 for their insights and will remove lines 51-52 and reword lines 53-56 to better align with the first half of the paragraph.

Line 68: Alternatively “situated in a hillslope landscape”

The authors will reword the current phrasing in the text “on a hillslope landscape” to this better suited suggestion.

Line 91-91: I don't understand the function of this sentence in relation to the next sentences.

The authors will reword the sentence to clarify that the alder shrub communities situated on the steep hillslopes exist in exclusively alder patches, whereas, in the alder savannas that exist on lowland water tracks, alders exist but are interspersed by other shrub communities.

Line 160: A sentence on how $\delta^{18}\text{O}$ from H_2O (soil solution) in your NO_3^- is derived would be useful here.

The authors thank Anonymous Referee #2 for this suggestion and will add in a sentence to clarify where $\delta^{18}\text{O}$ from H_2O came from: “Isotopic data for $\delta^{18}\text{O}$ - H_2O was measured directly from soil pore water samples using a GV Instruments Multiflow peripheral instrument (Heikoop et al., 2015).”

186-190: Iron, sulfate and Manganese enter the story a bit abruptly here. If they have a function in the study design (as it is later clear that they have), please add a sentence earlier when explaining the study scope and strategy, adding the function of measuring those parameters.

The authors thank Anonymous Referee #2 for bringing this to our attention and will add in a sentence to section 2.2 Sample Design to explain the importance of these supporting redox sensitive elements to our experiment earlier in the text.

Line 269: You define all the other pools, but SON is not defined (Soil Organic Nitrogen, I assume)?

The authors thank Anonymous Referee #2 for identifying this oversight. Yes, SON is Soil Organic Nitrogen and the authors will properly define this abbreviation the first time it is referenced.

Line 284: This is an interesting finding from this study

The authors thank Anonymous Referee #2 for noting this and will add additional text to the conclusions section to circle back to this point.

Line 290-91: This statement, referring to Boshers et al. (2019) should be explained further. While the equation 1 is nicely explained previously, the argumentation for choosing this method should be discussed in relation to alternatives. You mention that “both possibilities” (line 291-292) are shown in figure 5. By this, I take that you mean the H₂O-derived only and the Eq. 1 determined predictions (?), however, I see only one interval of predictions in figure 5. The text and the link needs a better explanation.

The authors thank Anonymous Referee #2 for this comment. Figure 5 should contain an additional predicted $\delta^{18}\text{O}$ range. The current range displayed is based on calculations from Kendall and McDonnell (1988) and a second should be added to show the predicted range of $\delta^{18}\text{O}$ based on calculations from Boshers et al., (2019). The authors will add in the additional predicted $\delta^{18}\text{O}$ range line for Boshers et al., (2019) to Figure 5 and better connect this figure to the text.

Lines 328-339: This section is interesting and coherent in its argumentation, but its place in the story of the manuscript is not clear. The point may be that there is a connection to the NO₃⁻ transport and –source, however, this link needs to be clearer for this section to be relevant to the overall story.

The authors thank Anonymous Referee #2 for this insight and are considering moving the isotopic story to the Supplement associated with this manuscript because it seems to detract from our primary findings and acts only as support to show that we investigated beyond just NO₃ transport: we also gained insights to the NO₃-N sources present at our field site but were unable to find a clear linkage between transport and source. Thus, these findings may distract from our transport findings more than they add to it so it may be most appropriate to briefly acknowledge that this data exists but we were unable to find a clear connection to transport and readers can reference data if interested in the Supplement.

Line 375-385: This section is a good example of clear, well-written communication/discussion of the results. !

The authors thank Anonymous Referee #2 for highlighting this section and will use it as a reference to improve and streamline other sections.

Technical comments with line numbering:

Line 19: The parentheses around NO₃⁻ concentrations are not necessary and should either be removed or the sentence restructured

The authors will restructure this sentence for improved flow and clarity.

Line 32: Consider using “near-surface hydrologic conditions” in order to exclude e.g. subpermafrost groundwater

The authors thank Anonymous Referee #2 and will change the language from ‘hydrologic conditions’ to ‘near-surface hydrologic conditions’ as aptly recommended.

Line 181: a comma is likely missing between “bags” and “frozen”.

The authors thank Anonymous Referee #2 for catching this typo and will add a comma.

Line 184: Soil temperature at which depth?

The authors took soil sample measurements from the depth at which each rhizon was inserted, which

was 15 cm for the majority of sampling locations. The authors will add clarifying details to this line of text.

Line 185: Introduce DO as Dissolved Oxygen before abbreviating

The authors thank Anonymous Referee #2 for pointing out this oversight and will identify DO as Dissolved Oxygen before using the abbreviation.

Line 200-201: Back up this statement with a reference?

The authors will add the following references to at the end of this statement: O'Donnell and Jones, 2006; Moatar et al., 2017.

*O'Donnell JA, and JB Jones. 2006. Nitrogen retention in the riparian zone of catchments underlain by discontinuous permafrost. *Freshwater Biology* 51: 854-856.*

*Moatar F, Abbot BW, Minaudo C, Curie, F, Pinay G. 2017. Elemental properties, hydrology, and biology interact to shape concentration-discharge curves for carbon, nutrients, sediment, and major ions. *Water Resources Research* 53: 1270-1287.*

Line 214: The beginning of this sentence should be reformulated – for once, the comma seems misplaced before “2017”

The authors thank Anonymous Referee #2 and will reformulate this sentence for improved clarity.

Figure 4: the lower part of the figure is cut off by the caption

The authors thank Anonymous Referee #2 and will ensure the caption does not cut off the figure for future submissions.