



EGUsphere, community comment CC1  
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## Comment on egusphere-2022-549

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Community comment on "Characterization of atmospheric methane release in the outer Mackenzie River delta from biogenic and thermogenic sources" by Daniel Wesley et al., EGU sphere, <https://doi.org/10.5194/egusphere-2022-549-CC1>, 2022

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Summary: The goal of the paper was to take a first look at the source of the hot spots previously found by aerial surveys using stable carbon isotopes within the Mackenzie River Delta (MRD). The authors state that the MRD has thermogenic gas seepage and biogenic methane atmospheric sources. Given there are so many lakes, this is not surprising, but there should be references for that statement. The authors hypothesize (line 84) that the hot spots come from "thermogenic, biogenic, and mixed sources....". This hypothesis could be strengthened by picking one source based on previous literature. For example, the Kohnert paper clearly suggests that the hot spots are thermogenic because they are so high, but didn't have any detailed source information to support this. This paper does. Or maybe the fact that there are so many lakes emitting biogenic methane means the atmospheric methane would make one hypothesize these hot spots would be biogenic? The strength of this paper is in using stable carbon isotope ratios of methane in air from ground surveys. The paper could benefit from some more details on the sampling sites, the sampling protocols, the assumptions going into the keeling plots, and overall conclusions drawn from the study. Overall, I think the data is interesting, and definitely novel and worthy of publishing. Hopefully the comments below could help streamline the message:

- The introduction could be streamlined and strengthened. Currently, the text suggests that the MRD has biogenic methane sources, but I couldn't see any references to support that. Maybe work from Lance Lesack's group would be helpful here for in and around Inuvik. On line 60, there is also mention of production of methane in the organic rich active layer but has no reference. There was a recent paper to conduct permafrost incubation studies (Lapham et al., 2021) in Tuk, but that didn't take place in the active layer. In terms of streamlining, the sentence from line 67-68 could be cut; while it is important to measure emissions of methane, since the current study didn't do this, it's not necessary.
- The study location and methods sections could be reorganized to be sure the proper information is conveyed in each section. For example, the setting was described in section 2, and then there was a "study location" in section 3. The methods section should only give the methods used, and results should be reported in the results section.
- Overall figures are sufficient with some revision. For example, figure 1 could be more

informative if the walking transects were shown on the pictures, and the direction of wind and location of seeps were also shown. As it is now, without any labels, it's difficult to see where the seeps are (unless you know), and at Lake 1, unless you know the picture shows the lake is ice covered, it's hard to know what is happening. The caption says "prominent ebullition" but unless you know what to look for, it's not clear with the captions. Furthermore, supplemental figure S2 is not mentioned in the text, yet addresses some concerns about wind direction and the location of the transects. If the quality could be improved, or information combined between figure 1 and figure S2, this could help.

- The chamber flux data seems to be an add-on. Is it necessary for the message of the paper? If so, more details will be needed (like how the samples were analyzed) and some context of what the fluxes mean in terms of other environments (for the discussion). If not needed, please consider taking out of the paper.

Detailed comments:

Line 34: add in "oxidation" after production and before transport. I think it's important with some of the conclusions drawn to get the idea of oxidation into the text earlier.

Line 51: As numbers, delta values can be high or low, positive or negative, but not heavy or light. Please use "high" or "low"  $\delta^{13}\text{C}$  values. Be sure to check this throughout and change accordingly.

Line 75: "geologic origin": maybe define what you mean and that it could be made up of thermogenic methane produced deep and migrates, or biogenic or rather, microbial methane produced in the permafrost? See comment from line 224.

Line 78-80: The sentence starting "interestingly, ...." Is a confusing sentence. How can the sources behave differently than the current understanding? Please reword to make more clear.

Line 117: it would be helpful to have a mark on the map for Tuk.

Lines around 119: describe your sites a little more than just a name. What is "site 9"? There isn't a description in figure 2, and on the figure 1 map, it looks like it's upwind of the hot spot from Kohnert. What were the winds like when you sampled it? Also, the sentence here of "Of the five airborne eddy covariance hotspots....." is a result. It should be moved to that section. In thinking more about the study design, if the idea was to ground truth the Kohnert hot spots, there is a missed opportunity to bring out some novelty of this study. For example, if we look at the "pingo 1" site, the fact that there is a pingo there is important, right? Does that already add information not gained from the Kohnert study? That you observed a pingo there? And what would that mean, what would the observation of a pingo mean for methane emissions? Aren't they by definition conduits of some sort? Or what about pingos being surrounded by wetlands? Additionally, at wetland 3, the fact that there are wetlands characterizing that hot spot is interesting information. I'd almost envision numbering the hotspots sequentially and then giving them their ground feature names as done on figure 1 (this is just a suggestion and maybe not helpful, it just seems interesting what ground features underlay the aerial hot spots). Yet, such an approach really send home the message that is directly inline with your goal, to groundtruth the aerial survey hot spots.

Table S1: The raw data should be available somewhere for review. Will it be available in a database somewhere, or as a supplemental table here? Also, in this table, for the "source  $\delta^{13}\text{C}$  values,  $R^2$ , and max  $\text{CH}_4$ " in the fourth column, those are the same values as in figure 1. I'm not sure what this table is adding except to give exact locations. Can you replace this with the raw data, from which you derive the y-intercept from keeling plots?

Also, Table S1 gives a "site type" as Polar V. How is the Polar V a site type? Also, you give into in this table for the low R2 values, what made you pick the R2 value cut offs you did? For example, you kept an R2 of 0.48 but didn't talk about the site with R2 of 0.434. This sort of thing should be mentioned in the methods.

Line 123: how did you determine where discrete point samples were collected? What was the strategy? Upwind, downwind, etc? This is a study location section, is this the best place for that information? I think you should be explicit that the strategy was to target the hot spots, and if you adopt a sample numbering scheme like numbering the hot spots, this strategy will be clear.

Line 125: Is "Lake 1" known as another lake by the community? Is that "shot hole" lake or Swiss cheese? And Channel Seep, is that channel seep 1? There could be reports that have some isotope data reported to help aid you in interpretations.

Line 126: the "observations of ebullitions seen in open water in summer", were those your observations made in this sampling trip or previous knowledge? Cite previous knowledge.

Line 126: how close is "as close as possible" to observed ebullitions? Were you on land, upwind, downwind? How long were walking transects, 10m? This discussion in these 3 lines around 130 are more about sample collection. As such, they should be moved to that section of the paper.

Lines 131-142: This paragraph seems more high level than where it is situated in the paper. I suggest reorganizing this study location section.

Line 149: Are you missing the word "under"? Permafrost "under" Tuk.....

Line 154: what is precision of handheld GPS and what model, make? What is the precision of the licor and the picarro CRDS? It's important to mention the cavity ring down spectrometer (CRDS) part of the instrument since that is how the measurement is made. And what standards were used to calibrate the concentration and isotope measurements? The placement of the analysis instruments seems out of place here since this is the sample collection section.

Line 156: Please cite the airborne work paper, since it was not done in this study.

Line 158: "photographs of each site...." I think this should be moved to study location, and not sample collection. You are using the photographs to describe the sites, correct? If so, they really set the stage for the setting, which belongs elsewhere.

Line 159: "walking transections..." what was pumping rate? What are dimensions of tubing? Is 6mm OD or ID?

Line 163: "Mixing between sample collection and analysis is limited due to small diameter of tubing". Have you proved that? Or is there a paper you can cite for this? The reason I ask is that the pumping rate is pretty fast, so I would imagine your sample will smear along the edges of the tubing and mix along the way it's filling. Please give more details as to the accuracy of this approach.

Line 166: Why did you pick 1 meter above ground level? Did you ever try to go down to ground level? Did you see any change in the concentration? Or is 1m desirable because things are more mixed and you are trying not to see a ground signal? What is the thought behind this?

Line 171: Where are the flux chamber measurement data? Also, this section is confusing

as written. It looks like 2 chambers were used, the automated one from Licor, but I can't tell what was used for Lake 1, using manual extraction of samples. And the dimensions are for a flux chamber, but there is only one, yet it seems two chambers were used? Also, can you discuss how only allowing 1 hour between collars installed and measurement might change your results?

Line 178: "Keeling plot analysis". I am not sure this is the right terminology. You analyzed keeling plots to determine the stable carbon isotope signature of the methane source. That phrase, keeling plot analysis, is used several times, so maybe it is the right term but it could be better to say "We constructed keeling plots with the discrete transect data to determine ...." And also cite the "common approach" of using keeling plots. I agree that it is common, but I am not sure it is common to take discrete measurements in the horizontal direction versus the vertical direction. Meaning, I thought keeling plots were always done in the vertical collection of air in a forest canopy, for example. If that is not true, it's probably still making a note of this since it does seem a bit novel to use this technique for the walking transects. Or maybe there are papers to show this approach used in this way.

Line 193: Do you have the bubble isotope values from historical data by the GSC to compare to your point measurements?

Line 197: Why is walking transect data shown as average data? The maximum value of 12ppm is very interesting and seems important to know where you were in comparison to the "wetland". Is it possible to do this from the GPS location data you obtained?

Line 203: The sentence of "estimates of source...." Seems a bit premature. Since this is the methods section, could you first say that the keeling plots are shown in figure 3, and show intercepts of X, Y, Z, which indicate the source of the methane? And also give the R<sup>2</sup> values? As it is now, you don't mention figure 3, so it's unclear where these numbers come from. The figure 3 caption mentions a "grey region" but there are no grey regions on the figures. And finally, there is a formatting issue with the equation written on the figures. It is also important to mention the cut off you used for the R<sup>2</sup> values.

Line 208: "Keeling plot values" is not quite accurate. Maybe say "keeling plot y-intercepts". It's interesting the seasonal component of these values. It seems reasonable to think that during the winter, there isn't as much methane oxidation, which leads to the lower values. I think you mention that in discussion.

Line 211: "Flux rates" isn't accurate. A flux is a concentration per area per time, a rate is distance per time. I think you just mean fluxes here. It also seems like the chamber fluxes are an afterthought since the fluxes aren't given here. And they are put in a supplemental table. Are they needed?

Lines 215-218: change "values" to "concentrations".

Line 217: take out "were". What is an "observation" in this context? There wasn't mention of observations before now. Where does the 2013 number come from? Do you mean the discrete measurements? Same question for the 1850 observations at pingo 1. This section is a bit confusing since it's also written like results, but yet in the discussion section.

Line 224: For the general reader, it might help to define geologic source in the introduction to put this conclusion in more context.

Line 240: Can you give values for the pingo 1 and 2 site in the text? It would help the reader not have to flip back to the figures.

Line 241: Is this new data? I didn't see the reporting of the methane concentrations over the pingo features themselves. And this sentence is also a bit confusing as to what you mean. Did you do 2 transects for Pingo 1? Seems like supplemental figure S2 (top right) could be helpful to show what you mean here. You could refer to that figure here, but that figure quality needs to be improved.

Line 243: Only wind speed is reported in table 1. Wind direction is also key that would be important to show in that table. Or did you always collect samples downwind? Do you see a correlation with wind speed? I would think that the higher the wind speed, the further away the source of that gas could be.

Paragraph starting at line 254: This is a great reason you chose to sample pingos. Could you move it to the introduction to help set up the "why" for your study? After reading the paper again, it seems you didn't set out to study pingos, per say, but you found those pingos at the ground features under the aerial hot spots. If you present these ground features as part of the results, I don't think you need to describe why you chose pingos to study, but instead, it will be clear why you sampled them.

Line 262: "these sites had no obvious geologic..." What sites are being referred to here: wetland 1, 2 and 3? If so, is there a hot spot at wetland 1? It's not obvious on the map. And wetland 3 is very close to swiss cheese seeps, correct? Seems like a potential geologic source.

Line 268: Can you add in a sentence after "...Wetland 3."? Please consider adding in: "Our data is consistent with knowledge that wetlands produce significant methane from microbial degradation. This carbon is also probably recent in age versus geologic methane." And you can give some citations for that.

Line 269: For the lack of signal at site 9, were you downwind of the wetland?

Line 273: Can you give reference for this?

Line 288: What is the evidence for thermogenic methane at this site? Is there any reason to think that the seep could be thermogenic? -53 from the keeling intercept still seems quite low for thermogenic. It just seems that this is most likely an oxidation signal. But as you say, it is still possible there could be thermogenic.

Line 294: I believe the location of Lake 1 is the same as "swiss cheese" that has been visited by the GSC before. Are there reports that report the bubble signature isotope value? It might be informative in your discussion of your values.

#### References:

Lapham, L.L., Dallimore, S., Magen, C., Henderson, L.C., Powers, L., Gonsior, M., Clark, B., Cote, M., Fraser, P., and Orcutt, B.N. (2021). Microbial greenhouse gas dynamics associated with warming coastal permafrost, western Canadian Arctic. *Frontiers in Earth Sciences* <https://doi.org/10.3389/feart.2020.582103>.