Reviewer's report on the manuscript by MacInnis et al. "Measurement report: The chemical composition and temporal variability of aerosol particles at Tuktoyaktuk, Canada during the Year of Polar Prediction Special Observing Period", Atmospheric Chemistry and Physics, Manuscript ID: acp-2021-262

The manuscript presents a report on the measurements carried out at a small Inuit community located near the Mackenzie River delta during summertime in 2018. The measurements include filter samples and continuous sampling using a particle counter. Analysis were carried out in an effort to characterise particulate matter compositions observed at this sites during the summer period. The manuscript is written as a measurement report, due to, I gather, some issues with the measurements (e.g., missing sample volume information, insufficient sampling period due to low concentrations) which resulted in certain limitations of the study. I do feel that the authors could extend the analysis a bit more to improve the interpretation of the measurement results and gain better insight into the observation at this remote Arctic site. My comments and suggestions are provided below.

2. Method and data analysis

2.1 Study area and sample collection

Could the authors provide some background on why this particular site was chosen and a description of the site and the area in terms of potential sources of aerosols?

The authors acknowledge that the sample volume could not be determined due to a file writing error so that air concentrations cannot be discerned from the filter samples. Were airflow rate and length of sampling controlled?

Is it correct that the particle counter has a lower size cut at 300 nm (so that particles smaller than 300nm are not measured by this instrument)? This seems to limit the ability to characterize aerosol size spectrum from this study as it misses Aitken mode almost entirely.

Were the inlets (filter sampling and particle counter) collocated?

2.3 QA/QC

Line 121: "the unanticipated, brief sampling period" – what do you mean?

Line 121 – 124: How should this low mass issue be taken into consideration with regard to the results shown in Figure 2?

2.4 Data analysis

Although the authors did include statistical summaries of meteorological observations (from the Tuktoyaktuk airport) during the field measurement period (Figure S1), it would be much more useful for data interpretation to plot the time series (e.g., wind speed/direction, temperature, humidity) as well.

3. Results and discussion

3.1 Aerosol filter masses

Line 167 – 169: The authors seems to suggest that the $PM_{2.5}$ and $PM_{10-2.5}$ masses based on filter measurements at this site were comparable (in terms of means and ranges; what about median?) and that the comparable masses between $PM_{2.5}$ and $PM_{10-2.5}$ were also shown from the global SPARTAN network sites (using the same instrument and analysis method). What does this imply? Is this corroborated by the mass estimates based on the particle counter measurements?

Line 169 – 171: Could the authors elaborate on this a bit more? How are the meteorological conditions related to the observed PM mass levels and how are PM levels affected by local and distant sources?

3.2 Chemical composition of aerosol filters

Figure 2 shows both the gravimetric masses and chemical masses from each of the filter samples. It would be interesting to see the mass differentials between the gravimetric mass and the total chemical mass from each of the samples to get an idea on how much of the PM mass is explained by the speciation and how much is unexplained (given that the analysis covers inorganic ions and metals but not organics). Perhaps this will provide some additional information for source identification under different conditions.

Is there any correlation between the variation in gravimetric masses amongst the filter samples and the variation in PM concentrations derived from the aerosol counter measurement?

Is sodium not analysed? Is sulfate shown including sea-salt sulfate?

Line 193 – 195: It might be good to rephrase this, as the only common feature shared in chemical composition of metals between Tuktoyaktuk and other Arctic sites shown in Figure 3 is the dominance of Al and Fe.

Figure 3: Are chemical composition profiles from other Arctic sites shown here based on summertime measurements also? If not, how might seasonal variability affect the comparison here? Also for the comparison do all sites carry out analysis for the same suite of ions and metals? For example, the Tuktoyaktuk profiles do not include sodium; does it mean that sodium is not present or just not analysed?

Line 211 – 214: Longer back trajectories are needed to better discern air mass origin (or influence) in the Arctic summertime, given that air mass tends to resides within the Arctic region for a long time (up to 2 weeks) in summertime (Stohl, 2006, JGR).

Line 235 – 240: Do the author imply that the Cl^- and Br^- detected in $PM_{2.5}$ and $PM_{10-2.5}$ samples, respectively could be of biomass burning origin? It would have been possible for Cl^- in $PM_{2.5}$ but one would not expect coarse particles to be transported from a long distance. It is still surprising not to see $PM_{10-2.5}$ sea salt at this coastal site.

It would be helpful to include a description of the local and regional sources (natural and anthropogenic). The influence of Smoking Hills emissions and Prudhoe oil fields could be discerned from trajectory analysis. For example, the August 3 sample could be influenced by sulfur emissions from Smoking Hills (based on the trajectory shown in Figure S2).

3.3 Size distribution, temporal variability, and health implications of aerosol particles

It should be noted that the aerosol number size distribution based on this measurement is incomplete as the measurement is missing Aitken mode particles almost entirely (with the lowest size cut at 300 nm).

Line 318: What do you mean by number size distribution being consistent with Herenz et al. (2018)? Their number size distributions show highest mode at ~40 – 50 nm under polluted conditions and just below 200 nm under clean conditions (their Figure 5). Those measurements were conducted during spring-to-summer transition period while this study is during summer period. One would expect to see quite significant differences in aerosol size distribution and chemical composition between these two different periods. Would this not be the case?

Table 1: Please clarify on $PM_{2.5}$ and PM_{10} measurements at the NAPS sites. They may be using different instrument/technique than that used in this study.

Line 326, Line 339, and Line 343: It may be more appropriate not to use the term “discrepancy” (or “discrepancies”) here. The differences are expected between these different northern sites, due to, as the authors pointed out, the differences in geographical locations, local and regional sources, etc.

Line 343 – 344: It may be better to say “… concentrations were lower during the summer of 2018 at Tuktoyaktuk than other locations in northern Canada”.

Figure 6: Since the time series shown in Figure 5 do not indicate a strong diurnal signal, I wonder how representative is the averaged diurnal profiles for PM mass concentrations. It would be good to plot the mean, media and inter-quartile range to indicate variability. The largest diurnal variation seems to be in the 2 – 5 um range – do the author have any explanation?

Line 374 – 376: It is better to just state that the $PM_{2.5}$ levels observed at Tuktoyaktuk is well below the national air quality standard. I would suggest removing the latter part of the sentence “suggesting PM_2 likely had minimal effects on the air quality of the community”.

4. Conclusion

Line 379 – 380: The authors stated that the analysis carried out could not identify distinct sources. Could the authors elaborate on the kind of information needed (or missing) for source identification? Simply stating that the site is influenced by a wide range of aerosol particle sources with complex processes seems overly general and nonspecific. What are the potential sources and processes influencing this site? It seems that the authors could delve into some of the available information (e.g., met and trajectory analysis) a bit more to gain some more insight into the observations at this Arctic site.