

Reviewer 1

This study presents valuable atmospheric measurements from the remote areas of the Northern Territories in Canada. Tuktoyaktuk is a hamlet representing both continental and Arctic Ocean maritime climate conditions in summer, and thus important location to obtain information on atmospheric composition. The authors provide detailed analysis on the chemical composition of fine (PM_{2.5}) and coarse (PM_{10-2.5}) aerosol filter samples as well as PM mass concentrations from optical particle counter. Although they faced difficulties with the quantitative assessment of ions in metals in aerosol particle filter samples due to their low chemical mass, characteristic for such remote area in the Arctic, the report is important and valuable for further research of such areas. Available scientific literature was used to relate the results with similar Arctic locations. There is no clear conclusion what were the exact sources of captured aerosol particles, but the discussion explained in full extent the possible scenarios from where these aerosols could have originated.

The paper is clearly written and the figures represent well the analyses. I would recommend publication of this work after some minor revisions. Particularly, authors could add more information into the introduction, explain the methods/results on aerosol filter masses analysis in greater detail, focus possible local natural sources of aerosol – high latitude dust sources, biomass burning and marine aerosol, and correct the references not cited in the text.

We thank the reviewer for their helpful comments. We have added information to the introduction, revised our paper to improve discussions of filter masses and sources of aerosol particles within the Arctic, and corrected references that were not cited in the original draft.

Specific comments:

C1. L31-32, , L39-42 – consider to include the study of Boy et al. (2019) describing the role of aerosols in changing climate in the Arctic here.

Boy, M., Thomson, E. S., Acosta Navarro, J.-C., Arnalds, O., Batchvarova, E., Bäck, J., Berninger, F., Bilde, M., Brasseur, Z., Dagsson-Waldhauserova, P., Castarède, D., Dalirian, M., de Leeuw, G., Dragosics, M., Duplissy, E.-M., Duplissy, J., Ekman, A. M. L., Fang, K., Gallet, J.-C., Glasius, M., Gryning, S.-E., Grythe, H., Hansson, H.-C., Hansson, M., Isaksson, E., Iversen, T., Jonsdottir, I., Kasurinen, V., Kirkevåg, A., Korhola, A., Krejci, R., Kristjansson, J. E., Lappalainen, H. K., Lauri, A., Leppäranta, M., Lihavainen, H., Makkonen, R., Massling, A., Meinander, O., Nilsson, E. D., Olafsson, H., Pettersson, J. B. C., Prisle, N. L., Riipinen, I., Roldin, P., Ruppel, M., Salter, M., Sand, M., Seland, Ø., Seppä, H., Skov, H., Soares, J., Stohl, A., Ström, J., Svensson, J., Swietlicki, E., Tabakova, K., Thorsteinsson, T., Virkkula, A., Weyhenmeyer, G. A., Wu, Y., Zieger, P., and Kulmala, M., 2019. Interactions between the atmosphere, cryosphere, and ecosystems at northern high latitudes, *Atmos. Chem. Phys.*, 19, 2015-2061.

R1. We have added this reference to the revised paper.

C2. L37-38 – high latitude dust sources in the Arctic are active also in the winter. Please see examples here:

Mackay, J. R., & Burn, C. R. (2005). A long-term field study (1951–2003) of ventifacts formed by katabatic winds at Paulatuk, western Arctic coast, Canada. *Canadian Journal of Earth Sciences*, 42(9), 1615–1635.

Bullard J.E., Baddock, M., Bradwell, T., Crusius, J., Darlington, E., Gaiero, D., Gassó, S., Gisladóttir, G., Hodgkins, R., McCulloch, R., McKenna Neuman, Ch., Mockford, T., Stewart, H., Thorsteinsson, Th., 2016. High Latitude Dust in the Earth System. *Reviews of Geophysics*: DOI: 10.1002/2016RG000518.

Dagsson-Waldhauserova, P., Arnalds, O., Olafsson, H., 2014. Long-term variability of dust events in Iceland. *Atmospheric Chemistry and Physics* 14, 13411-13422. DOI:10.5194/acp-14-13411-2014.

Dagsson-Waldhauserova, P., Renard, J.-B., Olafsson, H., Vignelles, D., Berthet, G., Verdier, N., Duverger, V., 2019. Vertical distribution of aerosols in dust storms during the Arctic winter. *Scientific Reports* 6, 1-11.

R2. We have added these references to the revised paper and added a statement about mineral dust as a source of aerosol particles during the winter-spring period in the Arctic:

Page 2, lines 36-38

“However, natural sources of aerosol particles, such as mineral dust, have been identified in the Arctic during the winter-spring period (Dagsson-Waldhauserova et al., 2014, 2019; Bullard et al., 2016; Mackay and Burn 2005).”

C3. L66-67– Important aerosol-cloud climate feedback in the Arctic has been described by Murray et al. (2021) and Sanchez-Marroquin et al. (2020).

Murray, B. J., Carslaw, K. S., and Field, P. R.: Opinion: Cloud-phase climate feedback and the importance of ice-nucleating particles, *Atmos. Chem. Phys.*, 21, 665–679, <https://doi.org/10.5194/acp-21-665-2021>, 2021.

Sanchez-Marroquin, A., Arnalds, O., Baustian-Dorsi, K., Browse, J., Dagsson-Waldhauserova, P., Harrison, A.D., Maters, E.C., Pringle, K.J., Vergara-Temprado, J., Burke, I.T., McQuaid, J.B., Carslaw, K.S., Murray, B.J., 2020. Iceland is an episodic source of atmospheric ice-nucleating particles relevant for mixed-phase clouds. *Science Advances* 6, eaba8137, 1-9.

R3. We have added these references to the revised paper.

C4. L165-167 – Could you please explain better why the **PM_{2.5}** mean and maximum mass range from the filters **are higher than** for **PM₁₀**? Are there other studies facing the same results? Consider to use also median.

R4. It should be noted that the coarse mode reported here represents only the fraction of particles with aerodynamic diameters from 2.5 – 10 µm, and that the actual PM₁₀ is always higher than the PM_{2.5}, as expected. To clarify this, we now include the mean, median, and range of total coarse mode (PM₁₀) masses in the text.

Page 7, lines 184-194

“The fine (PM_{2.5}, mean ± SD, 15 ± 9 µg, median 15 µg), coarse only (PM_{10-2.5}, 14 ± 4 µg, median 14 µg), and total coarse (PM₁₀, 29 ± 10 µg, median 26 µg) aerosol filter masses were similar during the study period, with notable variability (Fig. 2). For instance, the masses range from 2.6-31 µg, 7.3-22 µg, and 17-44 µg in PM_{2.5}, PM_{10-2.5}, and PM₁₀, respectively. Snider et al. (2016) also reported that masses of PM_{2.5} (median 72 µg, lower-upper quintiles 42-131 µg) and PM_{10-2.5} (median 90 µg, lower-upper quintiles 44-154 µg) were comparable in filter samples collected across a global network of sites (i.e., Surface PARTICulate mAtter Network, SPARTAN) using an AirPhoton sampler, although the exact distribution is site-specific. For instance, comparable masses of PM_{2.5} and PM_{10-2.5} are not unexpected, considering coarse aerosol particle emissions are likely transient in nature (i.e., from local sources), and they may not have been sampled during the brief sampling period in this study. This is further supported by the mass distribution of fine and coarse aerosol particles measured by the particle counter, where the mass fraction of fine aerosol particles was occasionally higher than the mass fraction of coarse aerosol particles (Fig. S4). However, PM₁₀ masses in this study were always greater than PM_{2.5} masses, as expected.”

C5. L208-217 – These elements are abundant in dust from the high latitude dust sources. Consider to add discussion also on that here. Are you aware of some active dust sources in your region? MacKenzie River, lakes, beaches? For example peninsula north of Paulatuk is an active source in July (as on the SDS map, but also in winter as published). You can find the Sand Dust Storm activity index at this website: <https://maps.unccd.int/sds/> (choose July). Chemical composition of different HLD sources can be found here:

Crocchianti, S., Moroni, B., Dagsson-Waldhauserová, P., Becagli, S., Severi, M., Traversi, R., Cappelletti, D., 2021. Potential Source Contribution Function Analysis of High Latitude Dust Sources over the Arctic: Preliminary Results and Prospects. *Atmosphere* 12, 347-362.

Mackay, J. R., & Burn, C. R. (2005). A long-term field study (1951–2003) of ventifacts formed by katabatic winds at Paulatuk, western Arctic coast, Canada. *Canadian Journal of Earth Sciences*, 42(9), 1615–1635.

R5. We have discussed the possibility of other, high latitude dust source regions in the revised paper and included the recommended citations where appropriate.

Page 9, lines 242-246

“This could suggest that in addition to local sources, the presence of Al in filter samples was attributed to mineral dust emissions and atmospheric transport from other, high latitude regions within the Arctic (Crocchianti et al., 2021; Mackay and Burn 2005). For

example, it is possible that aerosol filter samples on 18 and 26 July (Fig. S1) were influenced by active dust sources near the North Slope of Alaska (<https://maps.unccd.int/sds/>).”

C6. L235-240 – Biomass burning could be an explanation of your results here including high fluoride abundance. Consider to investigate if there was biomass burning event before or during your study period.

R6. We agree that combustion activities could be a source of fluoride in our study. Unfortunately, we are unable to identify specific biomass burning event(s) before or during the study. It is difficult to assign a source to fluoride since it is derived from multiple sources in the environment (e.g., marine, mineral dust, and combustion aerosols). We discuss this challenge in the paper.

C7. L477-479 – Jacobi et al. (2019) is not referred in the text

R7. Thanks for pointing that out. We have removed this reference in the revised paper.

C8. L538-539 – Thakur and Thamban (2019) is not referred in the text

R8. Thanks for pointing that out. We have removed this reference in the revised paper.

C9. L555-557 – Willis et al. (2019) is not referred in the text

R9. Thanks for pointing that out. We have removed this reference in the revised paper.