Responses to the Reviewers

We would like to thank all three reviewers for their thorough comments on this manuscript, which helped to improve the paper. Our responses to general and specific comments are below.

The comments of the reviewers are printed in bold. All line numbers in bold refer to the original manuscript, all others to the revised version.

Reviewer 1

Reviewer general comments: This is a very solid study with important new results on the aerosol in the summer Arctic and its possible sources and effects. Besides the few detailed comments listed below I only have one major issue. Why were the rich and unique data on aerosol composition only discussed in connection with the case study and not also in the discussions of air masses? Recommendation: Accept with modifications and complementing discussion of aerosol composition.

Response - We want to thank Dr. Heintzenberg for his comments on this manuscript. With respect to his major point, we agree that there is also a complementary data set from the AMS that flew on the POLAR6 during the summer campaign. As he points out, we include those data only in the discussion of the case study over the western end of Lancaster Sound. The major reason to not include the AMS dataset for the entire campaign is that the paper was largely focused on the ultrafine particles for which the AMS does not provide direct composition measurements (with the aerodynamic inlet measuring aerosol composition with unity transmission efficiency from just above 100 nm to 700 nm). As well, the AMS data set is extremely full and is being analyzed for presentation as either one or two separate, stand-alone papers. This future work will address the sulfate, organic, ammonium, and MSA aerosol mass concentrations in the campaign. As well, detailed sourcing via investigating the relationship of the aerosol composition to the time spent previously in marine boundary layers (or over other terrain) will be accomplished with FLEXPART-WRF analyses. This new analysis is well beyond what could have been included in the present paper, which is already quite long. We included just a small subset of the AMS data in the present paper to complete the discussion of the case study.

Each of the additional points is addressed below:

Line 46 - Please cite the references that established the phenomenon of Arctic haze long before your first citation.
Response – There are many such references, and we selected the following four for inclusion here on lines 49-50 of the revised manuscript:

- Rahn, K. A., Borys, R. D. and Shaw, G. E.: The Asian source of Arctic haze bands, Nature, 268, 713-715, doi: 10.1038/268713a0, 1977.
- Heintzenberg, B. J.: Particle size distribution and optical properties, Tellus, 32, 251–260, 10.1111/j.2153-3490.1980.tb00952.x, 1980.
- Shaw, G.E. and Stamnes, K.: Arctic haze: perturbations of the polar radiation budget. Ann. N. E Ad. Aci. 338, 533-539, doi: 10.1111/j.1749-6632.1980.tb17145.x 1980.

- Barrie, L. A.: Arctic air pollution: An overview of current knowledge, Atmos. Environ., 20(4), 643–663, doi:10.1016/0004-6981(86)90180-0, 1986.

Line 52 - Again, the influence of the Arctic front has been published about decades before your first citation.
Response – Here, reference to Barrie (1986) has been included on line 53.

Line 85 - Define "main mode number density".
Response – We have removed bracketed terms. The terms "accumulation" and "Aitken" are sufficient here.

Line 91 - There is another, more general, explanation, (see Heintzenberg and Leck, 1994)
Response – Reference added at line 96 with text as follows: "and marine biogenic sulphur (Heintzenberg and Leck, 1994). "

Line 116 - To be complete you might want to cite Heintzenberg et al. (1991) even though no size distributions were measured.
Response – Reference and the following text added on lines 122-126: "Although no size distribution measurements were performed, Heintzenberg et al. (1991) measured vertical profiles of the total particle number concentration greater than 10 nm during June and July, 1984 over the Fram Strait-Spitsbergen area, and found a "rather uniform distribution" with altitude. Their measurements, however, were confined to 500 m-MSL and above."

Line 151 - Where do these transmission data come from?
Response – Reference to Leaitch et al. (2016) added on line 162.

Line 152 - There must have been a substantial temperature increase from ambient to inside the CPC. Did you estimate the potential shrinking and loss of volatile particles due to this temperature increase?
Response – We have not, but we have added a brief discussion of this point beginning on line 162: "Although the transfer of the aerosol from outside to the instruments is relatively fast (5 seconds and less), volatilization of some components of the particles may have occurred. However, it has been demonstrated that the growth of smaller particles by organic condensation occurs primarily by low volatility organic components (e.g. Pierce et al., 2012). Thus, the integrity of the smaller particles that are the focus of the discussion here is more likely to have been maintained. We do expect increasing line losses of particles with sizes decreasing from 10 nm. Therefore our observations will underestimate $N_{5\text{-}20}$."

Line 182 - "Floe"?
Response – Corrected to "flow" on line 198.

Line 384 - Explain "SIL" in text and figure
Response – SIL removed, and replaced with defined BL (boundary layer).

Line 545 - No "loadings", please!
Response – Changed 'loadings' to "mass concentrations" on lines 577-578.

Line 792 - No citations “in prep.”, please!
Response – Removed from reference list and changed to personal communication on line 590-591 and on line 710.