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Interactive comment on "Growth of nucleation mode particles in the summertime Arctic: a case study" *by* M. D. Willis et al.

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Response to Anonymous Referee # 2

We thank Referee # 2 for their helpful comments on this manuscript. Our responses to comments and the corresponding changes to the manuscript are detailed below in blue text.

General Comments

The manuscript "Growth of nucleation mode particles in the summertime Arctic: a case study" by Willis et al., describes physicochemical properties of atmospheric nanometersized particles during a summertime new particle formation event in the Canadian Arctic Archipelago. As the authors correctly point out, new particle formation events, which can form in summer in the Arctic due to clean conditions and higher photochemical activity, are considered to be an important source of cloud condensation nuclei in this region. Because of this, knowledge of the sources and mechanisms of these events are important in order to assess the coupling between terrestrial processes and the atmospheric hydrological cycle. This study makes an important contribution this understanding by providing high quality measurements. They are presently clearly, and in a well-organized manner. I cannot find many flaws in this study and manuscript; however since it is my job to provide helpful comments I offer the following suggestions that I hope might improve the overall quality of this manuscript.

1. Since the air mass for this day has spent a week over land (Devon Island), it would be helpful for the reader to know the nature of the land surface and possible sources of condensible gas precursors. According to MODIS land cover data (Friedl et al., 2010), as well as visual observations made during the campaign, Devon Island is covered by snow and ice. As mentioned in section 3.3.1, a photochemical source of volatile organic compounds from snow and ice is a potential source that cannot be discounted. However, our observations of methanesulfonic acid and trimethylamine suggests a significant marine contribution. We have added information on the nature of the land cover on Devon Island to section 3.1 and the relevant figure caption, to illustrate other possible sources of condensible gas precursors.

2. Figures 3 and 4. In the text, the authors discuss the lack independent behavior of the number concentrations of particles larger than 50 nm and those between 5 and 20 nm. That difference is best depicted by including the latter on top of the stack

of plots in Figure 4. Not such a big deal, but it would allow for closer comparison of the differences between these distributions. We agree that rearranging the figures in this way would improve the clarity of our discussion. All particle number traces (previously separated between Figures 3 and 4) are now included in one figure, and consequently all composition information from the HR-ToF-AMS is now included in one figure (previously separated between Figure 4 and 5).

3. Figures 3 b-e show steady growth of the nucleation mode as the aircraft samples downwind. Since "growth" is such a critical aspect of this manuscript (the word appears 52 times in this manuscript), this reader at least is interested in seeing an estimate of the growth rate. This should be feasible given the steady wind conditions and data obtained in this study. We certainly agree that growth in an important aspect of this manuscript. We have attempted to estimate the aerosol growth rate from the size distributions observed by the SMS and UHSAS between 82W and 81W (between 86W and 84.4W the number distribution appeared to be dominated by N5-20, with a mode of larger particles of consistent size near 100 nm). Such an estimation is complicated for three main reasons. First, we must estimate the advection time using the average wind speed (6.5 m/s) in the lower boundary layer, neglecting any turbulent motions and potentially underestimating the true transport time. Second, we measured size distributions with SMS (20-100 nm) with a scan time of 60 seconds (40 second up-scan, 20 second down-scan) meaning that we have a total of 10 size distributions over a large spatial area (82W to 81W), and that each size distribution is averaged over a distance of $\sim$4 km. It is certainly possible for the size distribution to change over 4 km; indeed, we see evidence for this in some size distributions that appear to contain more than one mode below 50 nm. Finally, using these 10 size distributions we must assume that aerosol growth is steady between 82W and 81W, and that the source of condensing material is located at a point to the west of 86W, in order to estimate a growth rate. Under these assumptions, along with the log-normal distribution function method described by Kulmala et al. (2012) and fitting two modes between 20 – 55 nm and 55 – 800 nm, respectively, we find that the mode of smaller particles grew at a

rate of 6.6 nm/hr. Additionally, we find the mode of larger particles present between 86–84.4W, peaking at $\sim$85 nm, decreased in size from 82W to 81W. This is likely because smaller particles were growing into larger sizes giving the appearance of a decrease in the geometric mean diameter above 55 nm. We believe that this relatively large estimated growth rate carries a significant uncertainty for the reasons described above, and therefore have chosen not to include this estimation in the manuscript.

4. Figure 6: correct x-axis to show more clearly the range of particle diameter (it appears that the range starts with sub-10 nm diameters). Also, if the diameter is on the x-axis starts at 300 nm, and the minimum detectable size is 150 nm, then why weren't smaller particles detected by ALABAMA? The x-axis of Figure 6 has been corrected to more clearly show its range. Due to limitations of the ALABAMA's optical detection and the transmission efficiency of the aerodynamic lens, the ALABAMA detection efficiency depends on size. Particles at approximately 400 nm are detected most efficiently, and particles smaller than approximately 300 nm have a much lower detection efficiency. Some particles down to 150 nm were detected during this flight. But, during the case study period very few particles between 150 and 300 nm were detected by the ALABAMA. The description of the ALABAMA size range (Section 2.6.3) has been modified for better clarity as follows: "Optical detection of aerosol limits the minimum detectable particle size to approximately 150 nm with particles at approximately 400 nm detected at the highest efficiency. The transmission efficiency in the aerodynamic lens limits the maximum detectable size to approximately 1000 nm."

Specific Comments

Minor editorial comment: For consistency, change the spelling of "sulfate" in Figure 4. This error has been corrected.

References

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