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Atmospheric Chemistry and Physics Discussions

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Interactive comment

Interactive comment on "Observed aerosol suppression of cloud ice in low-level Arctic mixed-phase clouds" *by* Matthew S. Norgren et al.

Anonymous Referee #2

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This study uses long term cloud radar and aerosol scattering observations to try and determine the effects of aerosols on the microphysical properties of mixed phase Arctic stratus. While this study is timely and sorely needed, I feel that their criteria for determining what is an ice cloud at the minimum are not well explained and need to be better justified as their criteria can easily include liquid clouds with drizzle or even larger cloud droplets. Since this affects most of their dataset I feel that this issue is the most important to address before I can accept this for publication. I also recommend the authors explain the aerosol indirect effects with more detail in the introduction and consider the possible role of secondary ice production processes such as the Hallett-Mossop process and, from more recent laboratory experiments, the formation of ice from spicules that form from frozen droplets.

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Line 15: “ice nucleation” – do you mean reduced secondary production or reduced nucleation via increasing the liquid water content and therefore decreasing total available supersaturation?

Section 1, Paragraph 5, introduction: I think a more detailed introduction to the three indirect effects in mixed phase clouds are needed: the thermodynamic indirect effect, the glaciation indirect effect, and the riming indirect effect. Figure 1 of Jackson et al. (2012) provides a good summary of Lohmann and Feichter's three mixed phase indirect effects.

Section 1, Paragraph 6: This paragraph seems to be out of order and interrupts the flow of the paper. I think the information here belongs more to where you discuss how phase partitioning is critical, as it helps to justify why we need to study the phase partitioning of mixed phase clouds.

Section 2.1, Paragraph 1: What is the minimum detectable signal of this radar? A monodisperse size distribution of liquid drops with a concentration of 100 cm-3 and maximum dimensions of 20 microns (radius of 10 microns) should result in a reflectivity of about -20 dBZ, which is quite characteristic of the tops of single-layer arctic stratocumulus. Establishing approximately how small of particles the MMCR is sensitive to is critical as liquid cloud droplets have been observed in arctic stratus at temperatures as low as -30 degrees Celsius and I fear that observations of “small ice” that are pointed out in later sections could really be liquid drops.

Section 2.3. I think that the current criteria to eliminate as many liquid clouds as possible might be too simplistic. Liquid cloud particles can exist at temperatures as low 30 degrees Celsius, and even drizzle has been observed at temperatures as cold as -10 degrees Celsius. The authors need to better establish how sensitive the MMCR is to the smaller liquid particles, or perhaps only include regions that are subsaturated with respect to water but supersaturated with respect to ice in order to adequately ensure that they are only observing taking observations from ice in the clouds.

Page 8, line 14. These can easily be liquid droplets. Section 4.2. How much of an impact do you think the Hallett-Mossop process, active at temperatures from -3 to -8 degrees Celsius, would have in your higher LWP bin clouds in terms of secondary production? It may not necessarily be more riming, but there could also be more secondary ice crystals being produced by this process. Laboratory experiments have also shown that when droplets freeze they can produce spicules that then proceed to generate secondary ice crystals (see Lawson et al. 2015).

Figure 4. The color scale for reflectivity needs to be adjusted.

Figures 5, 6, 7. I found the figure legends difficult to understand with all of the entries and abbreviations. I would recommend revising the legends to make the figures easier to understand.

References: Rangno, A. L., and P. V. Hobbs (2001), Ice particles in stratiform clouds in the Arctic and possible mechanisms for the production of high ice concentrations, J. Geophys. Res., 106(D14), 15065–15075, doi:10.1029/2000JD900286.

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