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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The observed influence of local anthropogenic pollution on northern Alaskan cloud properties" *by* Maximilian Maahn et al.

Anonymous Referee #3

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The authors use airborne observations from June-September, 2015 within 90 km of two DOE-ARM sites (North Slope Alaska or NSA and Olitok Point or OLI) to study potential effects of changes in aerosol particles on Arctic liquid water clouds. The aerosol observations are limited to physical measurements with a PCASP (particles larger than about 100 nm) and a condensation particle counter (CPC; particles large than about 3 nm as well as measurements of black carbon (rBC). The main objective is to see if clouds formed on particles from anthropogenic activities in the OLI area result in differences in cloud microphysics compared with cloud formed on particles observed in the NSA area. The topic is relevant for ACP, the paper is well organized and interesting, and I believe the overall results are useful. However, the paper is not

currently ready for publication.

Major comments:

1) The paper leads up to section 6 (Quantification of cloud aerosol interaction) by accumulating information suggesting the microphysics of the OLI clouds are impacted by local emissions. That notion is then set aside in section 6 based on the calculated ACI indices. However, the ACI calculation in inappropriate for these observations if particles smaller than 100 nm are nucleating droplets. Drawing a 1:1 line in Figure 12 indicates some points above. Assuming the measurements are reasonably accurate, which the authors do not discuss, then relatively few droplets are nucleated on particles smaller than the lower limit of the PCASP. The larger deviations above the 1:1 line are towards lower aerosol concentrations, which would be consistent with Leaitch et al. (ACP, 2016) if there are sufficient particles smaller than 100 nm to explain the deviations. As it stands, the ACI discussion tells us only that there is some impact of PCASP-sized particles on the NSA cloud observations, which has already been mentioned in connection with Figure 10 and is not the focus of the paper. The fundamental result could be more clearly shown using Figure 12 with straight concentrations rather than natural logarithms. What do Figures 8, 9, 10 and 11 tell us that cannot be found from a modified Figure 12?

2) Concerning Figure 6 and related discussion on page 10, I have the following questions and remarks:

a) The differential collection growth rates (OLI minus NSA) range between 0.1 and 1 (units of kg/sm3). The mean collection growth rates vary from less than 10ˆ(-12) to about 5x10ˆ(-6) with the same units. How can the differential rates be higher than the mean rates? Are the differential values ratios (e.g. OLI-NSA/NSA) rather than absolute values?

b) On lines 3-4, you say that "C" is lower at OLI compared with NSA for constant LWC and Reff. This is very difficult to see in 6a. Regardless of whether the differentials

(OLI-NSA) are absolute or ratios, they are higher, not lower. Also, how do I look at constant LWC and Reff in these plots?

c) On lines 10 and 11, you say that the mean value of C (averaged for Reff) is 1 to 1.5 orders of magnitude reduced at OLI for a constant LWC. Yet the mean OLI growth curve lies to the right of the NSA curve, which indicates a higher mean collection growth rate.

d) The same apparent discrepancies are present for the rainfall rates in Fig. 6b.

3) The aerosol observations are restricted to below 500 m-msl. Please indicate the altitude range for the cloud observations. Please indicate how you know that the aerosol below cloud was connected with the cloud above and not isolated by temperature inversions, which can happen in the relatively stable environment of the Arctic.

Minor comments:

4) Page 2, lines 4-5 – Aerosol number concentration or mass concentration? If number, what sizes? This statement is very simplistic.

5) Page 3, line 18 – what are “bulk” probes?

6) Pages 3 and 4 – If not described, references are needed for how the CDP, DCDP and OAPs were evaluated and calibrated during the study.

7) Page 4, line 6 – A droplet threshold of 10/cc may not be appropriate for Arctic summer clouds (e.g. Leaitch et al., ACP, 2016), and it does not allow consideration of situations such as discussed by Mauritsen et al. (ACP, 2011). Please discuss.

8) Page 4, line 10 – what are “tiny” particles?

9) Page 5 – Describe the inlet for particles measured with the CPCs.

10) Page 5, line 11 - How was the PCASP calibrated during the study? Is the lower detection limit truly 100 nm (e.g. Liu et al.: Response of Particle Measuring Systems airborne ASASP and PCASP to NaCl and latex particles, Aerosol Sci. Technol., 16,

83-95, 1992)?

11) Page 5, line 20 - How as the SP2 calibrated?

12) Page 5, line 23 – While Arctic Haze is not common during the summer, how can you be certain it was not observed? PCASP number concentrations of 150-200/cc may be representative of Arctic Haze (e.g. Leaitch et al., J. Atmos. Chem, 9, 187-211, 1989).

13) Page 5, line 35 – A particle density of 6 g/cm3 is very high. The density of submicron particles is usually less than 2.5 g/cm3. Please explain.

14) Page 6, line 12 – aerosol data

15) Page 6, line 23 – reference for size of freshly emitted soot?

16) Page 6, line 26 - qualify “quickly” by assuming sufficient gaseous precusors.

17) Page 7, line 22 – smallER

18) Page 7 - In Fig. 4, there are interesting similarities between the small group of yellow points associated with each site. Both groups show increases in PCASP size with increasing CPC. This curious group is related to cloud for the OLI case but not the NSA case. Can you identify a connection?

19) Page 9, line 1 - Indicate the reason for the 16 um line in the caption of Fig. 5. Also, in Fig. 5, please add a line showing how LWC vs LER varies assuming the mean droplet number concentration for each location. What are those mean droplet concentrations?

20) Page 12, lines 1-3 – Is there evidence that OLI emissions impacted any of the NSA observations?

21) Page 12, lines 9-10 - Reduced Reff with increased rBC is not so clear; these plots have a qualitative aspect to them. At the higher LWC (>0.1 g/m3) that may be true, but

below 0.1 it appears that the opposite may be true.

22) Page 12, lines 15-16 - When averaged over a large number of observations. Also, the "notion" is commonly anticipated for clouds with higher LWC (roughly >0.1 g/m3; e.g. Leaitch et al., JGR, 1992) when effects of evaporation, dissipation and precipitation are reduced factors.

23) Page 12, Lines 18-20 – The use of monotonic is not justified here.

24) Page 13, lines 8-9 - How many CCN are needed for cloud formation?

25) Page 15, header for section 6 – You are not discussing an “interaction” here, only a potential impact of the aerosol on the cloud.

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