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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosols indirectly warm the Arctic" *by* T. Mauritsen et al.

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Thank you for your positive assessment and constructive comments. Yes, indeed we had a dual channel microwave radiometer (Westwater et al. 2001) onboard, and it are upon this instrument that assumptions on background liquid water path is based. We unfortunately forgot to mention this in the text, which we have corrected.

It is an interesting point raised about climate models applying minimum cloud droplet number concentrations. We would, however, be concerned with criticizing this approach as we lack the proper insight on model formulation details in all - but one - such model. Though if this a general and well known feature, which is documented in a study, we would be likely to include such a reference.

Detailed points:

1) We believe changes in CCN concentrations could be both natural and anthropogenic. Hence, at this point in the discussion we would prefer to stay general.

2) As mentioned above we did have a microwave radiometers onboard for estimating liquid water paths. The attached figure 1 shows the distribution of measured LWP. The median value is 67 gm-2, which we believe is a typical value for the frequently occurring low-level Arctic stratus. Values higher than 100 gm-2 were mostly related to deeper synoptic systems. The instrument has an error of +/- 25 gm-2, which is the reason negative values occur. This is also the reason we were unable to utilize the measurements for studying the low-CCN cases, because during these cases LWP was very low. The assumed geometrical thickness (dz) of the cloud of 335 m is based on the assumption of the liquid water content (LWC) of 0.2 gm-3 (Curry 1986, Verlinde et al. 2007, Shupe et al. 2008) and the assumed liquid water path: dz = LWP/LWC = 67 gm-2 / 0.2 gm-3 = 335 m.

3) We had two identical instruments measuring CCN. One was setup to monitor at a fixed supersaturation of 0.2 percent, which is typical of stratus clouds. The other instrument was scanning various values. A higher supersaturation value will yield more counts, though how much varies in time. The sensitivity of the measured CCN concentration on supersaturation depends a number of variables including particle size distribution, chemical properties, such as solubility and surfactant properties, morphology and state of mixture. The attached Figure 2 shows how CCN count and activation ratio varied in time over the experiment. An increased assumed supersaturation would therefore tend to shift observations to the right in Figure 2 in the manuscript to various degrees. As mentioned in the text, we found cases which were particularly sensitive to the supersaturation (marked blue). These blue dots tend to lie to the left of our curves, and one could speculate that in these cases more aerosol particles were actually activated in the cloud. A discussion of these issues is found on the bottom of page 16781.

4) In our simple model we allowed CCN to affect LWC and thereby LWP whenever a

threshold effective radius is reached. This is consistently done, under the assumption that the geometric thickness of the cloud stays constant. Technically, the radiation transfer model only sees the LWC, not the LWP. If we would assume a lower background LWP we would shift the modeled curves to the right (see Garrett et al. 2002, their Figure 3). The results were found to depend more on the threshold effective radius, which is indicated by grey shading, than to the choice of background LWP within reasonable bounds.

The assumed value for the threshold effective radius is based on in situ measurements of stratus clouds from other studies (Gerber 1996, Garrett et al. 2002, both referenced on page 16778). Typically, it is found that drizzle starts somewhere between 12 and 18 micron. Sensitivity to the choice between 10 and 30 micron is indicated by the grey shading in Figure 2. A further qualitative constraint on the droplet size is by the infrequent occurrence of double, or higher number, of fog bows. Unfortunately, these were not monitored regularly, evidence is based on personal photographs.

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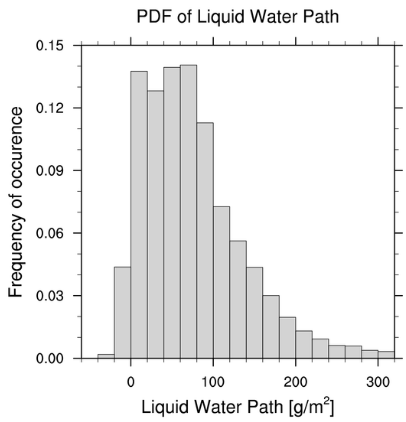
PDF of Liquid Water Path
Frequency of occurence
0.15
0.12
0.09
0.06
0.03
0.00
0
100
200
300
Liquid Water Path [g/m2]

Fig. 1.

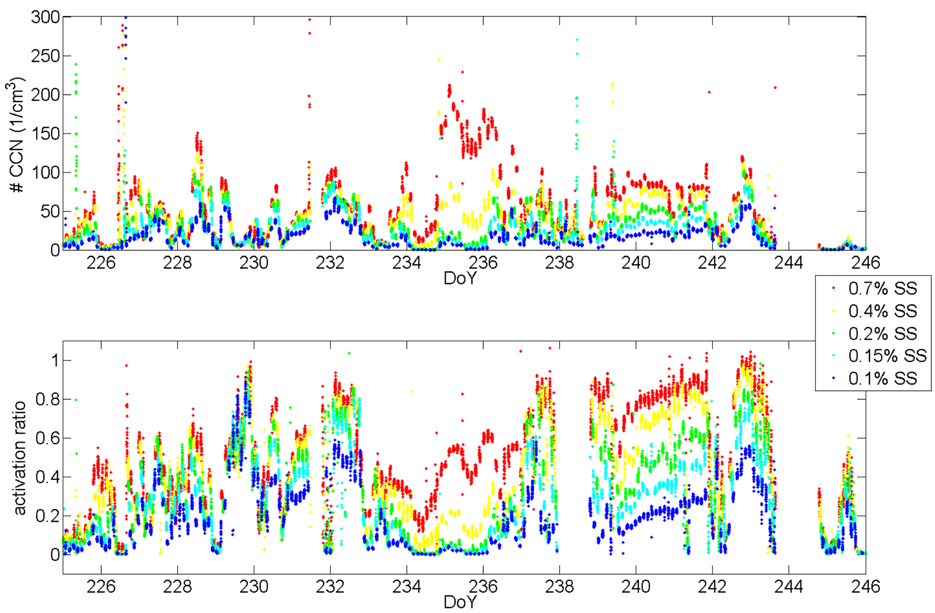
CCN (1/cm3)
300
250
200
150
100
50
0
226
228
230
232
234
236
238
240
242
244
246
DoY
0.7% SS
0.4% SS
0.2% SS
0.15% SS
0.1% SS
activation ratio
1
0.8
0.6
0.4
0.2
0

Fig. 2.