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Atmospheric Chemistry and Physics Discussions

Interactive comment on "On microphysical processes of noctilucent clouds (NLC): observations and modeling of mean and width of the particle size-distribution" *by* G. Baumgarten et al.

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General Comments:

This manuscript addresses a study of the size distribution of particles in noctilucent clouds (NLC). In particular it examines the relationship between the width of the distribution and the mean particle size. Three color lidar measurements from the ALOMAR site in Northern Norway show that the Gaussian width of the particle size distribution is proportional to its mean radius for mean particle sizes up to 40 nm. For larger particles,

the width becomes independent of the mean particle size or decreases with increasing particle size, depending on how the measurements are analyzed, although there appears to be small subset of cases where the width of the distribution continues to increase with increasing mean radii beyond 40 nm. These measurements are consistent with microphysical modeling results with the CARMA model. The model results show that the width of the NLC particle size distribution is largely driven by the eddy diffusivity. This manuscript represents one of the first studies showing that the width of the NLC particle size distribution can related to the mean radius. My recommendation is that the manuscript be published subject to the authors addressing the detailed comments below.

Detailed Comments:

1) Abstract, lines 5-10: Rather than simply saying that the width of particle distribution for particles larger than 40 nm deviates from the linear dependence observed for the smaller particles, you should indicate that the width of the distribution becomes independent or exhibits a slight decrease with mean size. While a slope of 0.39 +/- 0.03 is smaller than a slope of 0.42 +/- 0.02, it is not obvious the difference is either meaningful or statistically significant. Also you should make clear that this refers to the particles less than 40 nm.

we updated the manuscript accordingly: "For the vertically resolved particle properties (Δz=0.15 km) the slope is comparable and about 0.39±0.03. For particles larger than 40 nm the distribution width becomes nearly independent of particle size and even decreases in the lower part of the layer."

2.) Page 3608, line 15-16: How are the 3 segments defined? Equal thirds of the cloud? Or does the "Peak" exceed some fraction of the maximum backscatter? Or do you use some other criteria? Also given in the rest of the Manuscript you refer to the Top, Peak, & Bottom, for consistency you should use Top & Bottom here instead of "Upper" & "Lower".

We have updated the manuscript and include the definitions of the segments in the text. We also consistently use the terms Top & Bottom now.

3) Page 3610, lines 26-27, and Table 1: Why show "all" cases separately from the "statistical", cases, if the latter are more statistically reliable and include 90cases anyway. I recommend just showing the "statistical" results, or provide justification for showing both "all" and "statistical" cases separately.

We prefer to show both results as the "statistic" class has been investigated in several papers. We provide justification in the manuscript: "We apply the analysis to two different cloud classes "all" and "statistic" where the latter only includes clouds with $\beta_{\text{max}} > 4\times10^{-10}$ *m*$^{-1}$ *sr*$^{-1}$*. While clouds with* $\beta_{\text{max}} \leq 4\times10^{-10}$ *m*$^{-1}$ *sr*$^{-1}$ *could bias the trend analysis due to year-to-year changes in the instrument sensitivity the particle properties are still reliable (Fiedler et al., 2003)."*

4) Page 3611, lines 1-6: While it might be true the particles with r $>$ 40 nm are disproportionally near the bottom of the cloud, both the cloud peak (-0.08 +/- 0.02) and the cloud top (-0.05 +/- 0.02) also have negative slopes for r $>$ 40 nm. So you still need to explain why when all three parts of the cloud when looked at separately have negative slopes when you look at all parts of the cloud together (although with higher vertical resolution) you have zero slope.

The questions 4 and 5 have been answered together in a new paragraph of the discussion section:

Varying turbulence might also be responsible for the different slopes observed for $r >$ *40 nm in Fig. 1 to Fig. 3. We observed that method 1 shows a zero slope for* $r >$*40 nm while methods 2 and methods 3 resulted in negative slopes throughout the layer. When looked at the size distribution with the highest vertical resolution we find a larger fraction of clouds with large particles and high distribution widths. This results in a zero slope for* $r >$ *40 nm at the highest resolution (method 1) while the two other methods show a negative slope for* $r >$ *40 nm. From the model calculations we realize that distribution widths larger than about* $s =$*20 nm originate from elevated turbulence. It was previously observed that elevated turbulence can occur in narrow layers (*$\Delta z \ll$*1 km, Strelnikov et al., 2003). Such narrow layers might be visible in the high resolution data but suppressed when averaging the data vertically (methods 2 and 3). ...*

5) Page 3611, lines 9-16, and Table 2: You should make the distinction between the slopes for r $<$ 40 nm and for r $>$ 40 nm here. While it appears that there is not statistically significant difference in the slopes for r $<$ 40 nm, for r $>$ 40 nm, at least for type "I" and for type "B" the slopes for the faint clouds are significantly different from those for the strong clouds.

The questions 4 and 5 have been answered together in a new paragraph of the discussion section:

... The analysis of different cloud classes (Table 2) shows that for methods 2 and 3 the slope is typically negative for strong clouds and for medium clouds at the cloud peak and bottom. So for those cloud classes we observe less clouds with large particles and a wide distribution but more clouds with large particles and a narrow distribution. This might indicate that large particles in medium or strong clouds occur more often with reduced turbulence.

6) Page 3612, lines 4-14, & Figure 4: There appears to be a small subset of size distributions where the width continues to increase with the mean radius up to particle sizes of 80 to 100. The lidar data (especially Figure 1), also appears to have a small population of cases where the width increases up to mean radii of 60 nm.

Yes, we attribute these observations to cases with elevated turbulence. This point is addressed in the answers to questions 4 and 5.

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