Review of "Impact of particle shape on the morphology of noctilucent clouds" by J. Killani et al.

General Comments

This paper describes the impact of non-spherical ice particles in NLC simulations, addressing both the microphysical and optical properties. While many previous studies have looked at the optical effects resulting from non-spherical ice, the present study is novel in that it simulates the impact of non-spherical ice on NLC microphysics as well. The results are applicable to ACP and are for the most part clearly presented. The results support the conclusions, the abstract, and the figures and citations are appropriate. I recommend that this paper be published after the concerns below are addressed.

Specific Comments

1) It is interesting that cylinders give greater backscatter than spheres in the simulations. There is an important question, however, that is not currently addressed: is this due to greater ice mass density (m), optical effects, or both? This is an important point in the interpretation, i.e., is higher backscatter simply higher m, or can it go the other way? Understanding this aspect of the results could lead to very different interpretation of the lidar measurements. For example if all the curves in Fig. 7 have the same m vs. altitude, then determining m from a given backscatter observation depends heavily on knowledge of the particle shape. Additionally, many instruments can only infer NLC mass-related properties (e.g., IWC), and thus attempts at relating the lidar to these instruments could be affected. I recommend including a second panel in Fig. 7 that shows the m versus altitude for each model case (or add this panel to Fig. 8).

2) A very important aspect of this study is how the new results for non-spherical ice may change the interpretation of observations. To this end, it would be useful to estimate what changes would be expected in the NLC particle size and IWC determined from lidar (e.g., do the inferred radii and IWC increase or decrease and by how much). In addition, the information in Fig 9 seems like it would be important for other investigators who would like to consider your results. For example, is it possible to parameterize these probabilities in order to capture your shape distributions in the forward model of some other instrument? While this may be outside the scope of your paper, it is the kind of information others would appreciate.

3) There has been a debate of sorts in the NLC community concerning particle shape. In particular Rapp et al [2007] used the ALOMAR lidar data with modeling to arrive at axial ratios of ~5, while many satellite experiments indicate values of around 2. The present study now uses the ALOMAR data with more advanced modeling to arrive at axial ratios of ~2.4. You should discuss the differences and acknowledge the changes in your results from the Rapp et al. paper (probably in the conclussions).

Technical Corrections

1) Throughout: "Figure" and "Fig." are used alternately, be consistent with the style specified by the Journal.

2) Abstract, line 5: State here that the modeling of cylinders was both microphysical and optical.

3) Abstract, line 10: State that the relative probability of certain shapes is determined by the model (I believe this is the case), which is important because it is based on the microphysics and not an assumption.

4) Abstract, line 11: Please define "stronger". Is this greater mass density, or greater lidar backscatter, or both?

5) 16020, line 22: "validated" should be "inferred"

6) Section 1: It would be useful here to include a brief summary of the axial ratios reported by previous authors, for example, Baumgarten et al. [2002] indicate $\varepsilon < 2.5$, Eremenko et al. [2005] indicate $\varepsilon \sim 2$, Rapp et al. [2007] determined ε of ~ 5 or 0.2, etc…

7) 16021, line 14: "to NLC" should be "in"

8) 16022, line5: sentence "r is the…" is redundant to previous statement.

9) 16022, line 7: You keep the particle axial ratio constant during growth or sublimation. However, if ice accumulates uniformly on a cylinder, the axial ratio will change. For example, consider an initial length = 10 and diameter = 20 nm ($\varepsilon = 2.0$), adding a 10 nm layer of ice uniformly to the sides and ends gives $\varepsilon = 1.5$. While this example may be overly simplistic, it indicates that particles become less asymmetric as they grow. You should discuss this possibility and also review the growth of asymmetric particles (which borrows from electrostatic theory, i.e., think of the magnetic field lines surrounding a polarized rod).

10) 16024, line 10 (and elsewhere): "number density" is typically used in reference to gas molecules, "concentration" is the term generally used to describe the number of aerosols in a volume of air.

11) 16024, line 12: define the acronym "CR"

12) 16024, line 22: insert "(Figure 3)" at the end of this sentence.

13) Figure 3: The numbers in color (presumably radii) need to be described in the caption. The caption should indicate that these results are simulations. The curves in this figure are not easy to understand, and you need to add statements in the caption that help the reader in this regard. For example the oscillating colored lines are confusing, what causes this modulation? Also, what changes along the (grey scale) solid, dot, and dash lines? I assume it is particle size but you need to clearly describe this in the caption. Does $\varepsilon = 1$ refer to spheres or cylinders? Are all the results for cylinders? I ask because the text says Fig. 3 is for cylinders, but Fig. 4 says there are results in Fig 3 for spheres. The caption should state all relevant information. Many of the above comments apply to other figures as well.

14) 16024, line 22: This sentence needs clarification: "Since small particles (i.e., r < ~XX nm) are difficult to detect by lidar, having similar…"

15) 16024, line 27: "UV/Vis" should be "the UV/VIS ratio".

16) 16025, line 1: "particles up to" should be "particles with radii up to".

17) 16024 & 16025: This discussion needs to refer to Figure 3 more often, that is, let the reader know when a statement is illustrated in the Figure.

18) 16025: lines 15-25: Did the model runs for various particle shape use the exact same atmospheric conditions (e.g., T, H2O, winds)? Please clarify this aspect of the simulations.

19) 16026, line 15-16: This sentence needs to be reworded.

20) Figure 5: State the details for the observations used: the latitude, years, days of year, and altitudes (were these at the altitude of max backscatter?). What are the numbers (20, 40, 60, 80, 100, 120) in the figure? What is chi squared = 54.53 referring to (you describe this after discussing Fig 5)? "only spheres" should be "simulation for spheres", or, remove it from the Figure because the caption states this. It is hard to discern color for the model contours.

21) Figure 6: The model result contours are hard to see, can the lines be thicker?

22) 16028: These paragraphs are somewhat tedious in that they spend much of the readers time reiterating what can be seen in Fig. 6. This section could be reworded to arrive at the punch line, which is that one of the cases gives the best re-production of the observations, telling us the reasons for this agreement. In addition, the text refers to the simulations as "(b)" or "(e)", which seems to be the corresponding panel in Fig. 6. The correct way would be to either cite the Figure completely, e.g., "the results in Fig 6b", or to previously define model runs as a through f (for example in 16025 lines 21-25), and subsequently refer to "scenario a" or "model a". In either case it would be useful to occasionally remind the reader what scenarios a - f are.

23) 16028, line 27 "extend" should be "extent".

24) 16029, line 10: state here that Fig 7 shows simulations.

25) 16030, line20: "growing visible" do you mean "growing to sizes that are visible to lidar" or "to human eyes"? Perhaps simply state to r > XX nm.

26) 16030, line 23: "r^{5-6}" should be "r^5 to r^6".

27) Table 2: It would be instructive to add a column for the ratio of IWC / B_{int} for all the cases. This will help in addressing the concerns in Specific Comment #2 above.

28) Figure 8: Caption should state that these are model results. Also please clarify what equivalent radius is.

29) 16031, line 4: Please elaborate on what is meant by improved growth conditions.

30) 16031, line 9: Please quantify "brighter" (in % preferably).

31) 16031, line 10: The distributions in Fig. 9 are rather interesting, in that I assume they develop in the model due to growth rates and fall speeds varying in axial ratio. If this is correct, then the text should discuss this point. Is the initial shape distribution in the model a flat line (same number of particles in each ε bin)? Please clarify.

32) Figure 9: The inset text is small and difficult to read. While the specific classes of particle shape can be found in Fig 6, this is tedious to transfer, and it would help to repeat the information here. Do not plot the zero values, which results in the near-vertical lines at the termination of a curve. Finally, the y-axis notation of "[% max]" is cryptic, "normalized probability (%)" would be better.

33) 16031: This discussion needs to refer to Fig 9 more specifically (e.g., Fig 9d, etc…) and more frequently, to aid in understanding the results.

34) 16031, lines 15-23: These statements seem to be important, that is, the model indicates that elongated shapes are much more common than spherical shapes. It would add to the paper if you discuss the reasons for this in more detail. For example, is it because of the increased growth rate, or reduced fall speeds, or both?

35) 16032, line 21: Elaborate on what "nearly perfect conditions" means.

36) 16033, line 2: what is the standard deviation of the mean ε? In determining the average of values <1 and >1, did you do anything to the values <1, for instance use them as $1/\varepsilon$ when computing the average?