Responses to Reviewer 1:

"CALIOP V4 Cloud Thermodynamic Phase Assignment and the Impact of Near-Nadir Viewing Angles" *by* **Melody A. Avery et al.**

Summary:
The authors would like to thank two reviewers for carefully reading our paper. We appreciate the supportive comments made by both reviewers and we are happy to make the suggested minor changes. In each case we have made the suggested change, which improves the clarity of our presentation, so we are grateful to the reviewers. For ease of tracking these changes we have itemized our action for each change suggested. Our comments are in blue, after each comment.

Reviewer 1:

Page 3, Line 19: I suggest removing "the" from in front of "CALIOP".

> Have done this, although the acronym describes a lidar system the sentence now reads:

" This paper describes upgrades and changes to cloud phase and phase confidence assignments made using measurements from CALIOP, the first-ever space-based polarization-sensitive lidar."

Equation (5): Is the last relationship meant to be "equal", as opposed to "nearly equal"? If it is indeed meant to be "equal", it would help to explain why the equality.

> The equation, taken directly from Hu et al., 2009 might be confusing as written. It is an approximation for 532 nm particulate depolarization, as explained by the sentence beginning on line 12, but we call it δ_{1064} to avoid confusion with δ_v, both approximations for δ_p that are used in the algorithm. So as originally written it is a definition. To simplify the expression, and to complement the text, Eq. 5 is now written:

$$\delta_{1064} \equiv \frac{\beta_{532,\perp}}{\beta_{1064,\parallel}} \approx \frac{\beta_{532,\perp}}{\beta_{1064} - \beta_{532,\perp}} = \frac{1}{\frac{\beta_{1064}}{\beta_{532,\perp}} - 1} \quad (5)$$

Page 10, Line 5: It would help to add a sentence on explaining why the positive correlation for water clouds (I guess multiple scattering?) and why the negative correlation for ice clouds (perhaps due to larger backscatter being associated with a larger fraction of HOI, which have a smaller depolarization than ROI?). Of course, readers could always look up the cited reference for more information but adding a sentence could make it more convenient and ensure that all readers understand the physical concept behind this spatial coherence test (which plays a significant role in the manuscript).

>To address this comment, we have added these two sentences starting on line 4:

 "This test is based on the observation that due to multiple scattering, γ'_{532} and $\delta_{p,eff}$ are positively correlated in water clouds. In contrast they are negatively correlated in HOI clouds because

specular reflections from HOI ice crystals in a cloud layer increase γ'_{532} but do not depolarize the light."

Page 10, Lines 26-28: I suggest clarifying whether it's the color scale that would be adjusted and mentioning that this adjustment is not shown in the figure. Most importantly, though, I recommend mentioning the appropriate correlation coefficient value in the text or including it into the figure. This would help because, just looking at the current figure panels, it is not clear that the correlation is indeed positive in the water sector.

> Adding the correlation coefficient is a good idea, thanks to the reviewer for the suggestion. The last sentence of this paragraph now reads:

" Further, at 0.3° there is a weakly negative correlation of -0.07 between backscatter and depolarization in the water sector, in contrast to a positive correlation of 0.38 at 3°, indicating a significant misidentification of water as HOI when the spatial coherence test is applied at the larger viewing angle."

Page 20, Line 9: The words "the view" seem to be missing in front of "from the west".

> We added this to the text.

Page 26, Lines 3 and 4 of the caption for Figure 16: It would help to explain what is meant by "granule". Just a few words saying that it's a roughly half-orbit extending from one terminator to the next could be sufficient. This word (and maybe the data selection used for Fig. 16) should also be explained in Section 5.2 (Line 4 of Page 28) for the sake of readers who jump to the conclusions right after reading the abstract, without going through the detailed text first.

> This sentence has been added to p. 26, lines 3 and 4:

" CALIOP data granules extend from one terminator to the next, thus dividing each orbit into separate daytime and nighttime segments."

> The paragraph starting on line 6 on page 28 now states:

" Looking at the V3 to V4 changes in cloud volume necessitates using 60 m vertical profile bins. CALIOP data granules extend from one terminator to the next, thus dividing each orbit into separate daytime and nighttime segments. The first 100 daytime and nighttime granules in each month during 2007 and 2008 were used for the comparison matrices shown in Figure 16. The distributions did not change significantly when more granules were included. As determined from this ensemble of profile data the high phase confidence cloudy volume detected at 5-80 km increased by 5-9% between V3 and V4."

Page 26, Lines 20-21: It could be interesting to include some thoughts on whether the increase in unknown phase is likely caused by the presence of unidentified HOI (or perhaps by surface reflection?). The same applies to the increase in cloud volume (Page 28, Line 3), which is only 5% for 3° view angle, but is 9% for 0.3° view angle.

> This is indeed interesting to consider, and not trivial to explain since we can't compare observations from both viewing angles during the same time period, and there is some natural variability that may be occurring. When comparing unknowns from both viewing angles, missing HOI seems more likely to be found at 0.3°, based on the layer 532 nm centroid temperatures. We added this discussion to the cited paragraph (which now occurs on page 28):

" At 3° almost all unknowns that are not due to a low CAD score occur with centroid temperatures between 20 and -20 °C, and slightly more than half of these occur below 2 km in the tropics where the lidar signal is more likely to be significantly attenuated and the Level 2 algorithms have increased errors compounded by extinction due to overhead cloud and aerosol layers. At 0.3° about 3% of the additional "phase unknowns" may be HOI that have negative depolarization, as unknown layers are also observed at -20 to -40 °C and can have $\gamma'_{532} > 0.02$ sr^{-1}. It may be possible to recover more than half of these as HOI with the effective HOI depolarization correction included in Version 4.5."

While the cloud volume increases less in the 3° data, there are more dusty aerosols; so we added a sentence on page 29, lines 16-18:

" This is also reflected in the smaller increase in total cloud volume from V3 to V4 in the 3° data, which has 0.5% fewer water clouds and 1.5% fewer ice clouds, but also has 5% more dusty aerosol bins than at 0.3°."

Page 27, Line 20: The section number 5.1 is missing from in front of the section title.

> We added this, thank you for catching this mistake.

Page 27, Lines 27-30: I suggest adding something along the lines of "The impact of" at the beginning of this sentence, if I am right in assuming that it is not the crystals themselves that we try to eliminate (by excluding clouds with HOI from the CALIOP products), but we try to minimize their impact on the retrieved cloud properties. Also, it would help to delete, replace, or explain the word "more", as I was not sure about "more than what"? Finally, for the sake of clarity, I suggest replacing "they also occur as" in Line 29 by something like "this is a fairly minor issue, as HOI affect".

> This is a good point as we are not trying to eliminate the ice, but want to eliminate specular reflections from the ice, and the "more" needs to be explained. This is a good example of being too close to a problem to communicate well. The sentence has been changed to clarify both points:

"Specular reflections from horizontally oriented ice (HOI) from smooth hexagonal faces of aggregates, columns or lofted plates in convection at higher altitudes may be more difficult to eliminate completely from the atmospheric data than HOI in stratiform clouds by adjusting the nadir viewing angle because they do not align horizontally in strong updrafts, but they also occur as only 0.5% of the observations at 3°."

Page 28, Line 30: I suggest adding "is" in front of "composed".

> Done.