Atmospheric Chemistry and Physics Discussions

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Comment

Interactive comment on "Characterization of Polar Stratospheric Clouds with Space-BorneLidar: CALIPSO and the 2006 Antarctic Season" *by* M. C. Pitts et al.

M. C. Pitts et al.

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Response to Referee#3

We would like to thank the anonymous reviewer for his/her critique of our manuscript. His/her helpful comments and suggestions have improved the paper.

Our response to the specific comments is provided below.

Referee's specific comments:

1. p. 7939, l.23: 'significantly larger range in background noise' Does 'larger range' imply that the mean of the background noise is higher or is the variability of the noise higher while the mean is the same? Please clarify.

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Since the data below 20.2 km have not been averaged as much as the data above 20.2 km, the variability of the noise on the data is larger below 20.2 km than above 20.2 km, but the mean is the same. We have clarified this in the revised manuscript.

2. p. 7940, l.1: 'we applied additional spatial averaging to all data below 20.2 km to closely match the resolution of the data above 20.2 km.' Could you explain how the averaging is performed? Especially how you achieved a horizontal resolution of 1.67 km from a resolution of 1.0 km?

This is a good point- we can't actually reproduce the identical 1.67-km horizontal averaging as applied to the data above 20.2 km. In the Level 1b files, the lidar data are actually replicated and reported horizontally at 333-m intervals. So there are 3 replicated points in every 1-km horizontal resolution sample below 20.2 km and 5 replicated points in every 1.67-km horizontal resolution sample above 20.2 km. We found that applying a simple 5-point horizontal smoothing to the data below 20.2 km would most closely match the noise characteristics of the data above 20.2 km and, in fact, worked as well or better than more complicated weighted averaging schemes.

3. p. 7940, l.4: 'in Fig. 3b.' The text and Figure caption implies that between Fig. 3a and 3b only the data below 20.2 km is changed. However, also the picture above 20.2 km is different.

There was an error in Fig. 3 in the original manuscript. This is now fixed and a corrected Fig 3 is included in the revised manuscript. The data above 20.2 km in Fig. 3a and 3b now match as they should.

4. p. 7940, l.18: 'that has single profile resolution of 540-m vertical and 5-km horizontal' It would be instructive if this final result could be shown e.g. as fig. 3c.

We have added a third panel (Fig. 3c) to Figure 3 that shows the image with the 5-km x 540-m resolution.

5. p. 7941, l.16: 'The spread of the background aerosol data is representative of the

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magnitude of the noise in the measurements (sigma = 0.32)'. How has this sigma value been determined? (All data above 198 K?)

The sigma value was indeed estimated using all of the data above 198 km.

6. From Figure 4 one can see that the noise of the background seems to increase with decreasing temperature (e.g. from 220 K to 200 K). What is the reason for this? Could you discuss if there is any need to account for this increase in the PSC detection scheme when entering the PSC-temperature domain?

The increase in the background noise with decreasing temperature is really an altitude effect that shows up as a temperature effect because temperature is decreasing with altitude in the ensemble of points shown in Fig. 4. It is not of geophysical nature, but caused by normalization of the total backscatter signal by the molecular signal which is decreasing exponentially with altitude. We do not make any explicit attempt to account for this increase in background noise in the PSC detection scheme. However, the detection thresholds are defined as the 99.5 percentile value of the ensemble of data above 198 K and this percentile value is likely to come from the data with the largest spread at temperatures near 198 K.

7. p. 7943, l.2: 'There is a peak in the cold (blue) distribution corresponding to the background aerosol at cold temperatures and a pronounced positive tail corresponding to the PSCs.' Is there an explanation why the maxima of the distributions in the right part of Fig. 5 are less than 1. Is this also the case for the 13 June high-temperature data?

As discussed in Section 3.1, we apply a 5-km horizontal median filter to the data to reduce the noise levels and eliminate radiation-induced noise spikes. Due to the noise characteristics of the data, the median statistic is smaller than the mean, so the median filter produces backscatter coefficient values that are systematically biased low. As a result, the scattering ratios of the background aerosol are less than 1. This is the case for all days. Since our PSC detection algorithm is based on relative increases in scat-

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tering ratio, the low bias doesn't impact our detection and, in fact, the median statistic is much more effective at eliminating noise spikes than the mean. However, for applications where absolute values are important, such as PSC composition discrimination, the median statistic may not be appropriate. We are currently examining alternative approaches for data smoothing.

8. p. 7951, l.9: 'The accuracy of the TNAT area calculations are dependent on the accuracy of the GEOS-4 and MLS gas species mixing ratio data, but it is unlikely these uncertainties are large enough to explain the observed discrepancy.' One should discuss here two items related to the use of MLS HNO3 data:

a. MLS HNO3 is only the gas-phase fraction of HNO3 and, thus, does not account for the HNO3 taken up by PSCs. The authors use the expression 'denitrification', but from the dataset itself it cannot be decided whether the missing HNO3 is still present in the particles or removed from the stratosphere entirely.

This is an important point that we neglected to mention in the original manuscript. MLS only measures the fraction of HNO3 in the gas phase and does not account for the HNO3 taken up by PSCs. Although MLS observed large decreases in the abundance of gas phase HNO3 during the winter, it is not possible to determine from the MLS data alone whether the HNO3 was removed from the stratosphere entirely (denitrification) or just taken up by PSCs. The same is true for MLS measurements of gas phase H2O and the implication for dehydration. We have revised this section and removed the words "denitrification" and "dehydration" from these sentences.

b. In version 1.5 of MLS HNO3 there is a high bias of about 30%. Has this been corrected for? If not, this would lead to some overestimation of the PSC area.

At the time of this writing, MLS V2.2 HNO3 data is only available for a small portion of the 2006 Antarctic winter season. Therefore, our analyses were based on the earlier MLS V1.5 data. Based on the V2.2 validation paper (Santee et al., 2007), the V1.5 HNO3 data is biased high in the stratosphere by about 30%. We have not explicitly

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corrected for this bias, but we have performed an experiment to quantify the effect of this bias on our analysis. Since the bias in the V1.5 data is fairly constant throughout the stratosphere (M. Santee, personal communication), we simply multiplied the V1.5 data by 0.7 and repeated the analysis. The 30% reduction in gas phase HNO3 does lead to lower values of TNAT and about a 15% smaller area of temperatures less than TNAT, but overall the impact is small with the area of temperatures less than TNAT still nearly a factor of 2 larger than the CALIPSO PSC area. We have added a few sentences in the text to point out this high bias in the V1.5 data and describe its impact on our results.

9. Chapter 4.4 'PSC Composition Studies' In my opinion this chapter could be skipped since it does not go into detail and a paper on PSC composition retrieval is anyway planned. Perhaps the authors can move a few parts into the conclusions.

Since the companion paper is lagging quite a bit behind this paper, we feel that a brief discussion of the capabilities of CALIPSO for PSC composition discrimination is useful.

Technical:

1. Figs. 12-18: daily time series, x-axis It would be easier for the reader if at least the months could be indicated.

Month names have now been added to the x-axis labels in Figs 12-18.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 7933, 2007.

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