Author responses to reviewer 1

Figure 1: add units to y-axis. Add a und b to the Figure.
The figure was updated accordingly.

Can you please add some information on the amount of PSC measurements per year and month, since the focus of the paper is on PSC measurements? It is not enough to provide the PSC days in Figure 9. Could you add the number of lidar observation during the PSC season and the number of PSC observations to the upper plot of Figure 1. And similar in Figure 1b, how often where PSC observed during the different month.
We provide PSC days because delimiting a PSC measurement is arbitrary, not a PSC day. Different methods, such as the one used by Snels et al. (2021) delimit PSCs as vertical bins, which is dependent on the resolution of the lidar design. How can one delimit a PSC in time and space? The only delimitation we consider safe is to say if a PSC was detected during a specific day, this is why we use PSC day.
To account for the reviewer's comment, we added the number of measurements conducted in June, July, August and September as blue stars in the top panel, as well as the total number of PSC days detected in June, July, August and September as green circles in the bottom panel.

Line 195: The used peak detection algorithm needs more explanation. It is not clear how the peak algorithm will work for the particle linear depolarization ratio profile? For example, an STS cloud has a very weak signal in the depolarization. How can a peak algorithm reliable detect such a signal? Also, from Figure 6 it is apparent that your miss to detect parts of the cloud and that the missed part is most likely STS. It would be good if you could provide examples of the you PSC peak detection.
The peak detection algorithm is performed on the total backscatter ratio and on the particle linear depolarization ratio. The results are combined to provide the set of scattering layers. The combination consists of a "logical or", which means that in the case of an STS, the identification of a peak in the R_T signal is sufficient.
As we explained in our first responses to the reviewer, the error in Figure 6 results from a misdetection of the boundaries of the cloud, which can occur with our method. We could have corrected it manually for the purpose of the Figure but we considered it more honest to leave it as it is.
The detection peak algorithm can lead to misidentification of the boundaries of a layer, especially in cases like the one shown in Figure 6 where multiple layers are present. Nevertheless, we consider its efficiency satisfying considering the other options available.

Another point we would like to highlight is that the detection peak algorithm is performed on 15 minutes lidar measurements for the purpose of Figure 6. This is a very short integration period which is not the one used for our climatology: usually we work with measurements integrated on 90 minutes at least. When processing this same measurement integrated on a longer time period, one can see on the figure below that the adequate layers are detected. On the figure below, the layers detected are delimited by horizontal black dashed lines. The red dots indicate the local peaks identified.

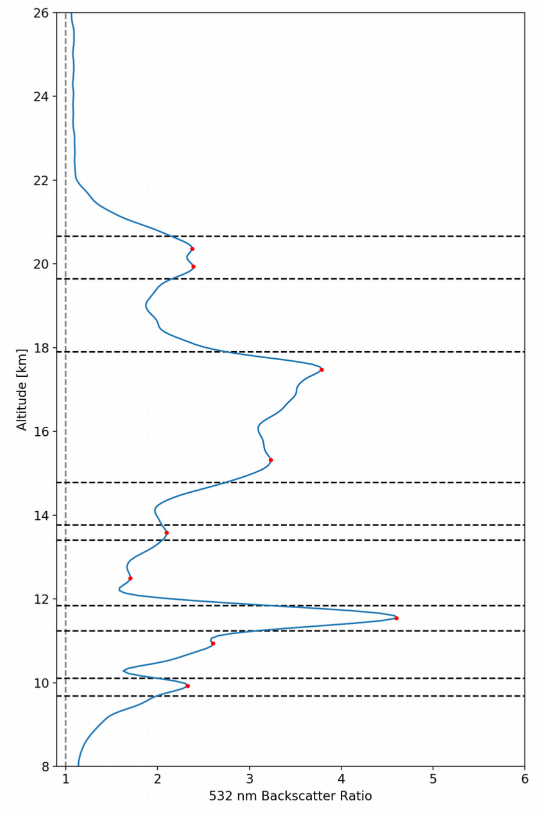

Figure 10. The description of the Figure provided in the paper is not sufficient. Can you add the description similar to the one provided in your reviewer answer to the text? Is the x-axis legend correct? If I understand correct thickness means the difference between HNAT – HPSC and the difference can be up to 15km?

"For each day with a PSC detection, we calculated the stratospheric range satisfying the condition T < TNAT. TNAT was calculated with the daily MLS H2O and HNO3 measurements. Let us call this range HNAT, expressed in km. We also calculated the geometrical thickness of the PSC detected, called HPSC. Then, we computed the difference HNAT – HPSC: it represents the stratospheric range satisfying T < TNAT unoccupied by PSC layers. The distribution of this difference, for all PSC detections at DDU from 2007 to 2020 is plotted in Figure 10."
The x-axis legend is indeed correct. This difference can reach values up to 13 km in some rare cases, the 15 km indicated at the right only concern the interpolation of the distribution. Such high values can be reached with a very cold stratosphere and only thin layer of PSC.

To address the reviewer's comment, the discussion of Figure 10 was complemented with the following text, lines 511-526: "To check this above DDU, for each day with a PSC detection, we calculated the stratospheric range satisfying the condition $T - T_{NAT}$. T_{NAT} was calculated with the daily MLS H_2O and HNO_3 measurements. Let us call this range H_{NAT}, expressed in km. We also calculated the geometrical thickness of the PSC detected, called H_{PSC}. Then, we computed the difference $H_{NAT} – H_{PSC}$: it represents the stratospheric range satisfying $T - T_{NAT}$ unoccupied by PSC layers. The distribution of this difference, for all PSC detections at DDU from 2007 to 2020 is plotted in Figure 10."
Now that $H_{NAT} – H_{PSC}$ have been defined in the manuscript, the x-axis label was edited accordingly.

Author responses to reviewer 2

Line 8: CALIOP acronym should be defined in the Abstract.

Edited line 8-9: "The Cloud-Aerosol Lidar with Orthogonal Polarization PSC detection"

Line 26: "... variations in account..." should be "...variations into account..."

Edited line 27: "into"

Line 34: suggestion replacing "..., which role..." with "..., whose role..."

Edited line 35: "whose role"

Equations 1-5: Suggest defining all the individual symbols for parallel and perpendicular aerosol/particulate backscatter, etc. Could just include them in the sentences where they are mentioned.

Edited, line 113-115: "… as a function of the parallel and perpendicular molecular backscatter coefficients ($\beta_{mol,//}$ and $\beta_{mol,\perp}$ respectively) and of the parallel and perpendicular particulate backscatter coefficients ($\beta_{aer,//}$ and $\beta_{aer,\perp}$ respectively)"

Line 126: "tropopause" do you mean "troposphere"?

Yes it was a typo and was corrected, line 129. Thank you.

Lines 130-131. PSCs may occur above 28 km- would this affect the clear-air reference calculation and calibration?

If such PSC would occur, it would indeed affect the inversion procedure. Such cases are very rarely met at DDU and when it is the case, the clear-air reference altitude is manually increased.

Line 210: "et" should be "and" ?

It is indeed a typo, corrected line 213: "… and ..."

Line 222: "As mentioned in introduction..." should be "As mentioned in the introduction..."

Edited line 225: "… the introduction"

Line 336: "... do not directly provides the PSC types distribution..." should be "... does not directly provide the PSC type distribution..."

Corrected line 336 as suggested: "... does not directly provide the PSC type distribution..."

Figure 5: The distributions shown for P18 over DDU are not consistent with Fig.12 in Pitts et al. (2018) where the 12-year statistics for the entire Antarctic region show STS occurring near TSTS and Ice occurring near Tice. Can you explain this apparent discrepancy?

Fig. 12 of P18 is based on 12 Antarctic winters for the whole vortex at 21 km. It is based on much more data than our local observations. In the case of CALIOP, the measurements of very cold ICE PSC fields within the core of the vortex probably explain the differences with our observations as they drive the distribution. The ICE PSC detected at DDU are on average observed at higher temperature due to the location of the station, at the edge of the vortex and once again the low number of ICE observations could on its own explain the discrepancy.

As for STS PSC, the formation temperature spans a few Kelvins depending on the HNO3/H2O fraction inside the droplet. In our case, we use the closest MLS profile both in time and space which is less accurate than CALIOP who can take advantage of its synchronicity with MLS. Moreover, as mentioned in the manuscript, we are not surprised by the gap between our observations and T_{STS} given the non-discrete nature of this variable.

Figure 5 caption: Sentence formatting needs fixed.

The formatting issue of the caption was addressed.

Figure 9: The black triangles are the CALIOP PSC days over DDU, correct? If yes, then they should be defined in the caption. It is surprising that CALIOP would have such a small number of PSC days. Is this based on a 100-km match distance? Why do you think the number is so small?

The caption was addressed to mention the black triangles. Edited in the caption: "..., and with CALIOP in black triangles."

Concerning the low number of CALIOP observations at DDU, it is indeed based on a 100-km radius area around the station. First, we expected this low number since Tesche et al. (2021) already mentions a significative difference in the CALIOP coverage between stations like DDU and the ones deeper inside the continent, such as Dome C Concordia.

First, the location of DDU at the edge of the vortex explains partly a lower number of PSC observations as compared to higher latitude sites. As Tesche et al. (2021) shows it, especially with its Figure 8, there is an important gap in profile avaibility between the stations located on the shore of Antarctica and the ones located deeper inside the continent.