Please find our reply below. Referee comments are given in black, our answers are given in blue.

Vincent Noel (Referee #2)

I am satisfied with most of the answers to my original comments.

The comment in which I request for a result was not clear. I'll try to do better below.

When PSC measurements are available from a ground-based site, I would expect the first result (before PSC speciation) presented to be the PSC Fraction, which would be defined (by analogy with tropospheric clouds) as the ratio of the number of lidar profiles in which a PSC can be detected, divided by the number of lidar profiles that sample the stratosphere over that location. 100% would mean that all sampled profiles contain a PSC, 50% half of the sampled profiles contain a PSC, etc. This number would inform on the ubiquity of PSCs over the considered area.

Using the authors' methodology, it should be possible to document, over a given location, the actual PSC Fraction (by considering all the profiles sampled by CALIPSO over that area), and the PSC Fraction that would be retrieved from a ground-based lidar (by considering only the profiles that would see the stratosphere considering the presence of opaque tropospheric clouds). From these results one could document the error in retrieved PSC Fraction over all the considered locations. That error might provide an additional data point to rank locations, as locations with smallest errors would enable the most accurate representation of PSC frequency. The numbers retrieved in this fashion would probably align with the accuracy of PSC speciation by location.

We would like to thank Vincent Noel for the follow-up comment. We now understand what the Referee was looking for. Right now, our statistics are restricted to those CALIPSO profiles for which PSCs have been detected. The Referee would like to see what the findings would look like if we were to normalise by the total number of CALIPSO profiles rather than only the number of CALIPSO profiles that show PSCs. Such plots have now been added to Figures 2 and 5. Figures 2b and 5b now show the ratio of all CALIPSO PSC profiles versus all CALIPSO profiles (i.e. the PSC occurrence rate) while Figures 2d and 5d show the ratio of PSC profiles with suitable tropospheric cloudiness for ground-based lidar measurements versus all CALIPSO profiles.

We understand the rationale of the Referee's question regarding the effect of PSC occurrence rate. However, our own experience with running a manually operated ground-based lidar for PSC observations shows that PSC occurrence rate is an ambiguous measure. First, it can only be defined properly in terms of a reference number for normalisation if a ground-based instrument is run continuously or according to a schedule with fixed measurement times. This is often complicated for a manually operated system run by a small team as measurement times are adapted to PSC occurrence. Second, measurements might not be performed if PSCs are absent to save laser lifetime, to perform calibration measurements, or to simply give the operator some time to rest. Finally, PSC statistics are generally obtained only for those lidar profiles that show PSCs.

Nevertheless, we appreciate the Referees suggestion and have revised Figure 2 and 5 accordingly so that the readers can also get an impression of PSC occurrence rates from the polar-wide plots. In addition, we have added the effect of PSC coverage for additional guidance towards finding the best location for ground-based PSC measurements as colour coding to Figure 8. This addition complements the current discussion of Figure 8 but doesn't change the conclusion of the analysis.

Figures 2 and 5 now look like this:

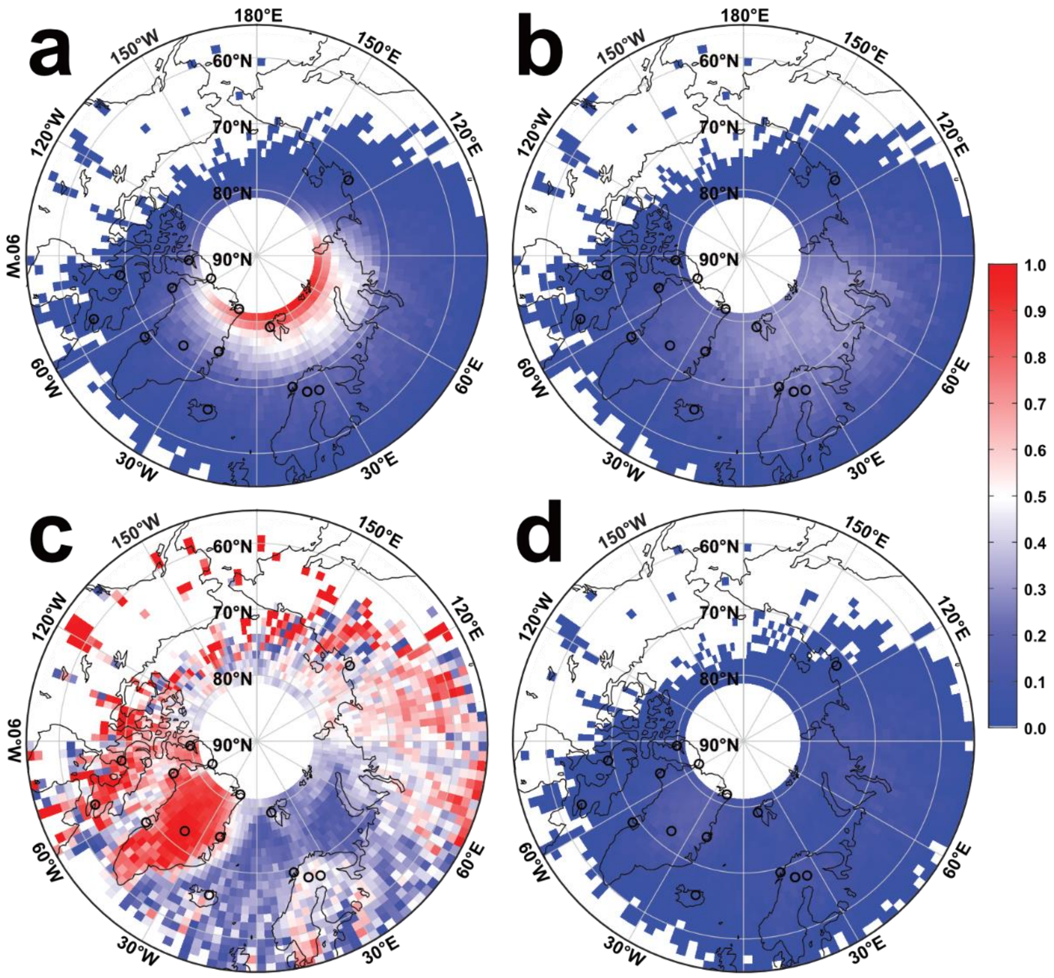

Figure 2. Normalised number of CALIPSO profiles with PSCs detected over the Arctic (a, scaled to maximum count of 2478), ratio of CALIPSO profiles with PSCs detected versus all CALIPSO profiles (with and without PSCs detected) for the same time period (b, PSC occurrence rate), ratio of CALIPSO profiles with favourable tropospheric cloud conditions for ground-based lidar measurements (no or only transparent clouds) and PSCs detected versus all CALIPSO profiles with PSCs detected for the same time period (c), and ratio of CALIPSO profiles with favourable tropospheric cloud conditions for ground-based lidar measurements and PSCs detected versus all CALIPSO profiles for the same time period (d). Black circles mark the locations of lidar ground stations shown in Figure 1 and listed in Table 1.

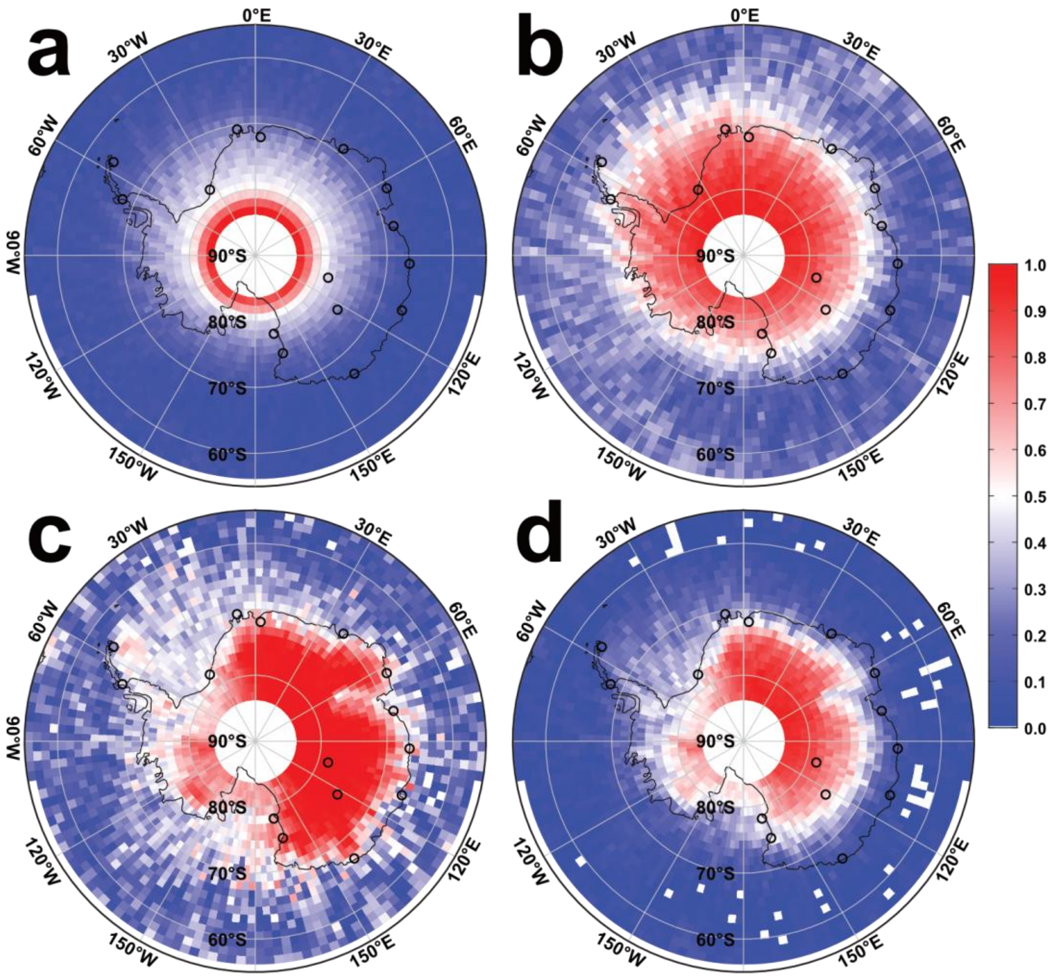

Figure 5. Same as Figure 2 but for the Antarctic. The display in (a) is scaled to a maximum count of 2001.

We have revised the discussion of Figure 2 accordingly and clarified that the closer look at PSC chemical composition only considers those CALIPSO profiles for which PSCs have been observed. New text is marked bold:

The absolute number of observed PSC profiles (normalised to a maximum count of 2478) and the PSC occurrence rate (the ratio of observed CALIPSO PSC profiles versus all CALIPSO profiles) are shown in Figure 2a and b, respectively. The absolute number of PSC observations is largest at highest latitutes due to the high CALIPSO return rate at those locations. The effect of the return rate is compensated for in the PSC occurrence ratio in Figure 2b. Overall, *Arctic PSCs are most abundant between 30°W and 90°E and north of 70°N. The pattern of the CALIPSO-derived PSC occurrence rate resembles the MIPAS-based findings in Figure 6b of Spang et al. (2018). Note that Pitts et al. (2018) derived PSC occurrence frequencies for fixed altitudes of ϴ = 500 K (around 20 km) and that the PSC area in their Figure 24 is thus smaller than inferred from considering all PSC height levels as done here. Figure 2a and b also show that the geography of the Arctic means that most ground stations are located in areas of relatively low PSC occurrence. This is levelled by the normalised occurrence rate of suitable conditions for ground-based observations presented in* ***Figure 2c and d. The difference between the two displays is that Figure 2c is normalised to the number of all PSC-containing CALIPSO profiles while Figure 2d is normalised to all CALIPSO profiles.*** *The region of highest PSC occurrence rate over the north Atlantic coincides with the highest occurrence of opaque tropospheric clouds. While Ny Ålesund could potentially observe the most PSCs in the Arctic, the occurrence rate of good conditions for ground-based lidar measurements is much lower than at* *the other Arctic stations. In contrast, sites on Greenland and in the Canadian Arctic show almost no opaque clouds but - with the exception of Villum - also feature a low occurrence rate of PSCs. A similar situation though with a generally lower rate of suitable conditions for ground-based observations is found for Alomar, Esrange, and Sodankylä. However, these sites provide much easier access than the other more remote locations. Tiksi is a station that could potentially provide information on PSCs over the Siberian Arctic.*

The occurrence rate of PSCs with different chemical composition in the Arctic for all-sky conditions is shown in Figure 3. Here and in the following closer look at Arctic PSCs, normalisation is done with respect to all CALIPSO profiles that contain PSCs (analogous to Figure 2c) rather than all CALIPSO profiles (as in Figure 2b and d). The Figure 3 *reveals that STS and NAT mixture are most abundant with a region of maximum STS occurrence over the north Atlantic and southern Greenland. The occurrence rates of NAT enhanced and ICE are well below 10% and neither shows an area of pronounced occurrence. The distribution of wave ICE in Figure 3e shows that this composition is restricted regionally to southeastern Greenland, around Iceland, southern Svalbard, the Scandinavian mountain range, and Novaya Zemlya.*

The discussion of Figure 5 was revised to refer to the correct plots in new Figure 5.

The revised Figure 8 looks like this:

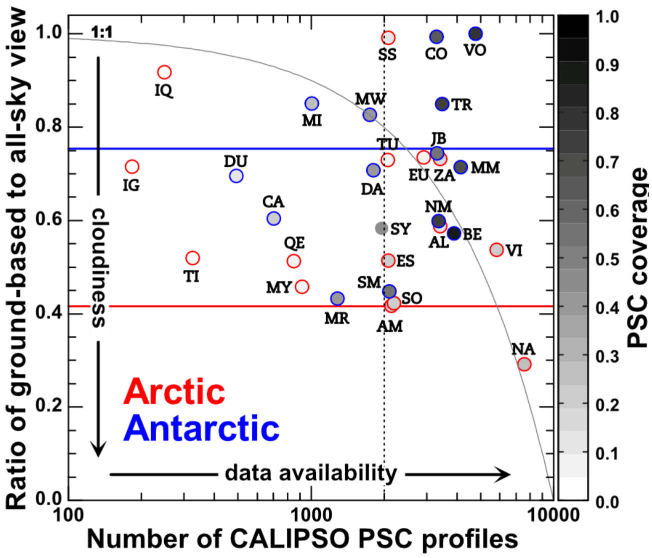

Figure 8. Number of CALIPSO PSC profiles in the 4◦×4◦ grid box centred around the Arctic (red) and Antarctic (blue) ground stations listed in Table 1 versus the ratio of PSC height bins as observed by a ground-based and a spaceborne lidar (columns 3 and 6 in Table 1). The colour coding refers to PSC coverage (ratio of PSC-containing profiles to all profiles) as shown in Figures 2b and 5b. Horizontal lines mark the values for the entire Arctic and Antarctic, respectively. The vertical dashed line separates stations with more than 2000 CALIPSO PSC profiles from those with fewer observations. The grey line marks a scaled PSC coverage defined as (10000 - x)/10000. Stations to the right of this line show a combination of tropospheric cloudiness and PSC coverage that indicates favourable conditions for ground-based lidar measurements. Stations abbreviations and markings for sites with published PSC climatologies are given in Table 1.

The discussion of Figure 8 has been revised to:

"Figure 8 combines the information on the absolute and relative occurrence of PSCs with the occurrence rate of tropospheric conditions that support PSC observations with ground-based lidar. This display helps to assess the likelihood for obtaining suitable amounts of data for studying PSCs

from ground-based lidar observations at the sites considered in this study. For the sites to the left of the dashed line that marks 2000 available CALIPSO PSC profiles, the number of PCS profiles in combination with the PSC occurrence rate is too low to consider the establishment of a new lidar station for PSC observations. To the right of the dashed line, further separation is provided by the grey line that represent a scaled PSC coverage. The most suitable stations for PSC observations from ground can be found to the right of this line because they combine a high PSC occurrence rate and a large number of identified PSC profiles with a high rate of favourable conditions for PSC observations from ground (upper right corner). Of the established PSC observatories only Concordia, Eureka, and McMurdo fall into this category. At Ny Ålesund, the large number of PSC profiles together with the high PSC occurrence rate (see Figure 2a and b, the PSC coverage of 0.29 at Ny Ålesund is the largest of all Arctic station) balances the measurement-inhibiting effect of a high occurrence rate of tropospheric clouds. Note that the assessment in Figure 8 is based entirely on atmospheric conditions and does not consider infrastructural challenges such as the accessibility, power supply, or availability of facilities at the respective sites; or the training and work load of the stationed personnel. It is because of this that most of the established PSC observatories fall into a region that could be considered as less suitable for establishing a ground station for PSC observations. Nevertheless, the trade-off between PSC occurrence and tropospheric cloudiness at those sites still creates conditions that allow for meaningful amounts of PSC observations — as witnessed by the available literature. If new PSC observatories were to be established, the most suitable choices – based solely on atmospheric conditions – would be Villum, Summit, Zackenberg, Thule, and Alert in the Arctic; and Vostok, Troll, Jang Bogo, Belgrano II, and Neumayer III in the Antarctic."