We would like to thank Vincent Noel for the valuable input. Please find out point-by-point reply below. Referee comments are given in black, our answers are given in blue.

Vincent Noel (Referee #2)

In this paper, the authors combine two CALIPSO cloud datasets to evaluate the amount of stratospheric clouds (PSCs) that could be detected by ground-based lidars at various polar locations, taking into account the optical obstruction of the lidar laser beam by tropospheric clouds.

The concept behind this study is simple and smart, relatively straightforward to apply once the datasets are made coincident in time and space, and in this study provide results that will be definitely useful to inform installations of lidar instruments in polar locations. In other words, I think the authors had a very good idea. For the most parts, they executed that idea well: generally the paper is clear and well-written, the figures convey the important points well, and the conclusions are useful. The article is short, which I appreciate, but perhaps a bit too short. I have a few questions for which I could not find answers in the paper, and I think some of the paper's results could be made clearer (see below).

Thank you for the overall positive feedback. Please find our detailed replies below.

Major points

1. My first major point is that while I think I understand how the authors processed profiles with stratospheric clouds and no tropospheric clouds, I'd like a clarification on how the authors decide, when tropospheric clouds are present, whether these clouds are transparent enough for a ground-based lidar to detect the PSC above (L. 105)? I expect the authors apply a threshold criteria on some integrated property of tropospheric clouds within the profile – is it on the geometrical thickness of the tropospheric clouds, on their optical depth, on something else? The value of the threshold might change from one ground-based lidar to the next, since one lidar with higher SNR might be able to penetrate further than another lidar with a smaller SNR.

We are sorry that this important point was not clear. Our approach is actually much simpler and doesn't require the use of threshold values or any information on cloud geometrical and optical thickness. For every matched profiles of tropospheric and stratospheric cloud observations, we check the cloud types in the 05kmCPro Vertical Feature Mask. We consider a profile as representing conditions under which a ground-based measurement could be performed, if the Vertical Feature Mask (i) shows no tropospheric clouds at all, (ii) shows only altocumulus (transparent), i.e. cloud type (v) in Section 2.2, (iii) shows only cirrus (transparent), i.e. cloud type (vii) in Section 2.2, or (iv) shows both altocumulus (transparent) and cirrus (transparent). As soon as any other type of tropospheric clouds in present in a profile (any of the four low-level cloud types, altocumulus (opaque), or deep convective (opaque), see Section 2.2), we consider this profile to represent conditions that are unsuitable for a ground-based measurement. Our definition of transparent clouds is already given in Section 2.2. For clarity, we have revised the first paragraph in Section 2.4 to:

"Information on cloud type from the Vertical Feature Mask in the 05kmCPro.v4.10 cloud profile product is used to sum up the number of height bins with different tropospheric cloudiness for each CALIPSO profile. This information is used to identify cloud-free conditions (a total of zero counts for each of the eight cloud types) and situations with only transparent tropospheric clouds that would still enable meaningful PSC observations with a ground-based lidar, i.e. altocumulus (transparent), cirrus (transparent), or a combination of the two. In addition, all-sky refers to the use of all profiles independent of tropospheric cloudiness."

Also, given a semi-transparent tropospheric cloud with a specific optical depth, a given lidar might be able to detect a relatively bright (larger backscatter) PSC beyond, but not detect a thinner one. Could you comment on how these considerations affect your results, or if they do not affect them at all? Maybe discussing the distribution of opacities of tropospheric clouds the ground-based lidars are supposed to go through would help evaluate if this is an important issue or not. These considerations might lead to location-dependent uncertainties of the approach, according to the distribution of opacities of tropospheric clouds and backscatter of stratospheric clouds over a given location.

These considerations have no effect on our results as we don't consider geometrical thickness of opacity of the tropospheric clouds. Instead, we rely on the CALIPSO cloud typing which depends on feature altitude (cloud top height) and opacity (whether or not clear sky can be detected below a feature). Because the CALIPSO laser emits less power than most ground-based lidar instruments for PSC observations, we are confident that a cloud that is transparent in a CALIPSO measurement would also be transparent in a ground-based observation.

2. My second point relates to the presentation of the results by location. Once I understood the premise of the study, the first thing I looked for is a figure presenting the amount of PSCs detectable by a ground-based lidar at each location (taking into account obstruction by tropospheric clouds), relative to the amount of PSCs actually present in the profile (and observable from space). That information might be present in Figure 1 (the numbers in each bar?), or Figure 8 (the y-axis?), but I'm not sure.

This is indeed the central information we want to convey by this work. We are sorry to hear that it was hard to figure out the actual numbers. The information on the fraction of PSCs that are observable with a ground-based lidar at a certain location can be taken from (i) the maps in Figures 2b and 5b (occurrence rate of favourable tropospheric cloud conditions for ground-based lidar measurement), (ii) the ratio of the numbers in Figures 4 and 7 (number of PSC height bins during conditions with no tropospheric clouds or transparent clouds only (middle bar) divided by number of PSC height bins during all-sky conditions (left bar)), and (iii) the y-axis in Figure 8 (ratio of ground-based to all-sky view, this was calculated following (ii)).

We have revised the text throughout the manuscript so that the information can be extracted more straightforwardly.

Regarding Figure 8, I am not sure I understand it correctly. I am under the impression the authors tried to create a single figure that somehow sums up the potential of each location for ground-based lidar observation of PSCs, but this attempt might be at the cost of ease of interpretation. For instance, the meanings of the grey lines is lost on me. Could you make it clearer somehow if that information is present somewhere in the paper, or add it if it's not there? I understand there is value in having a single figure that ranks locations according to their ground-based performance, but maybe the authors could consider spreading the information it contains on several figures to make it easier to discuss and digest?

We are sorry for the confusion regarding Figure 8. We agree that the interpretation of this figure was not straightforward. Following the suggestion of the other referee, we have already removed all but one of the grey lines and revised the figure caption to: "*The grey line marks a scale 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*."

We have revised the discussion of Figure 8 accordingly. We chose the display in Figure 8 as it nicely presents the two factors that define the rate of success for PSC measurements at a certain ground station: (i) the effect of tropospheric cloudiness (How often can we measure up to the stratosphere (while PSCs are present)?) and (ii) the occurrence rate of CALIPSO profiles that contain PSCs (How often will there be PSCs?). All stations to the right of the grey line are those that we consider to perform particularly well. This shows for instance that at Ny Alesund, the high PSC occurrence rate compensates for the low occurrence rate of favourable conditions for ground-based PSC measurements – leading to an overall favourable station location.

The information in Figure 8 can be used to produce a simple ranking of stations by multiplying the x and y values. The stations listed in the Abstract and the third paragraph of the Summary are based on such a ranking.

3. Another information I'd like to see: given a particular location, if we take the spaceborne-retrieved PSC fraction over a given location as the "truth", how off are the fractions retrieved from the incomplete ground-based retrievals at the same location? This would quantify the error or uncertainty in ground-based PSC retrieval from a given location. Depending on the seasonal variability of PSCs over a given location, it might provide a different way to rank the locations. A location with the best sampling might be affected by a larger error than another with a poorer sampling, if the PSCs over that last location do not change much.

We might have misunderstood the Referee's comment but the outcome of the PSC classification at different sites for different conditions of tropospheric cloudiness is exactly what is shown in Figures 4 and 7. These figures show the occurrence frequency of different PSC constituents for all-sky conditions (the "true" values), for favourable conditions for ground-based lidar measurements (the ground-based instrument measures whenever tropospheric clouds allow), and for conditions where external circumstances allow for only one third of the optimally possible measurements. We find different effects of tropospheric cloudiness. We also see that locations with poorer sampling tend to show a larger difference between the spaceborne and ground-based view. However, we are only looking at the long-term distribution of PSCs with different composition here and did not consider any seasonal variation.

In any case we would like to ask the Referee to confirm that this is what was meant by the comment.

Minor comments

1. L.26: "Today, we are confident..." I'm not sure we are that confident. There is definitely a consensus in recent studies that study PSCs to focus on three possible particle types (ICE/STS/NAT), but I'm under the impression this consensus has less to do with actual evidence showing that all PSCs are made of these particle types (meaning in-situ measurements) and more with a standardization around dominant retrieval algorithms and datasets. Please use a less confident statement, or correct my impression with references.

Thank you for pointing out that the availability of PSC in-situ measurements is still low. We have mitigated the statement to: *"Today, there is consensus that…"*

2. L. 77: "only the austral winters of 2012 and 2015 are are included in the analysis of Antarctic PSCs": Why is that? Why not use the same record for both poles? If one dataset is 3 years long and the other 12 years long, how does it affect our confidence in the results from both poles? (Also "are" is said twice)

This is a fair comment. We started looking at the coincidence of PSCs and tropospheric clouds in the Arctic based on the full data set for this pole. We later realised that a comprehensive documentation of the method and results in a research publication should consider both poles and this is what we did. However, the much larger amount of CALIPSO PSC observations translates into an increased amount of available data which is further doubled because we consider CALIPSO profiles for both tropospheric and stratospheric clouds, i.e. APro and PSCMask files. We started with two years of Antarctic measurements and found that those actually include more CALIPSO PSC profiles than the entire Arctic data set. So on the one hand, the volume of data is comparable at both poles. On the other hand, we checked that the Antarctic observations are in line with *Pitts et al.* (2018, https://doi.org/10.5194/acp-18-10881-2018). This means that we are confident that including a longer time series of Antarctic observations does not affect the overall conclusions regarding the assessment the representativity of long-term lidar measurements from ground.

Also, we have deleted the second are.

3. L. 93: "Maps of the occurrence..." Which maps are we talking about here? If this refers to the upcoming figures, why not wait until the figures are introduced to discuss the maps?

The normalisation is part of the data analysis methodology which is why we present it in Section 2.4. However, we have moved the statement to the next paragraph after data gridding is mentioned. In addition, we have added a reference to the figures for which the normalisation has been applied to:

"Maps of the occurrence of the accumulated number of height bins related to different PSC composition are normalised by the total number of PSC height bins per considered grid box (see Figures 2, 3, 5, and 6)."

4. L. 92 "a certain a PSC", "this types was"

The statement has been revised to:

"A CALIPSO profiles is referred to as containing a certain a PSC composition (e.g. STS-containing or ICE-containing) if the respective component is identified in at least one of the PSC height bins."

We have also replaced the reference to PSC type with PSC composition after the introduction.

5. Like another reviewer, I do not think the title is a clear description of what this article is about. Without reading the article it is unclear what the authors did. I understand the authors wanted the title to be more about PSCs and less about location ranking, but I find the current title to be less interesting than what the paper describes. It sounds almost obvious: "Location controls the findings of observations" is always true. The contents of the paper go beyond that, and the title might do the article a disservice. I'm not sure what a better title would be though.

Following the concern of both reviewers, we have revised the title to: ***"On the best locations for ground-based PSC observation."***

6. The approach presented by the authors here has, in my opinion, applications beyond the polar regions. It could be used to rank the potential of locations to provide ground-based observations of high clouds in other regions (eg Tropics), or evaluate the best use of mobile observation setups during campaigns, etc. Maybe the authors could include a comment to this effect in the conclusion.

The Referee is correct. The methodology can be adapted to find suitable locations for observations of mid-level or high clouds or elevated aerosol layers at which the effect of measurement-inhibiting low clouds is minimal. A corresponding statement has been added to the Conclusions:

"In addition, the methodology presented here can be easily adapted to assess the effect of low-level clouds on tropospheric observations. For instance, it can be used to find locations for measurement campaigns or long-term observatories at which the measurement-inhibiting effect of opaque clouds has a minimum impact on the observational cover of mid-level or high clouds and elevated tropospheric and stratospheric aerosol layers."