Response to reviewers' comments:

We thank Farah Khosrawi for her helpful and constructive comments. In the following we list our answers to specific suggestions and questions by the reviewer.

Technical corrections:

We included all suggestions except the last two which addressed the spelling of titles of references. In those cases we kept our original spellings, since they are identical to the spellings that were used in those titles. Yet, we are aware that they may appear uncommon.

Specific comments:

- P2, L32: We replaced "clouds" by "PSC".
- P2, L34: The sentence was rewritten and is now: "Over the period of operation the lidar data has been used to generate multiple global PSC climatologies with the latest version covering 11 years of observations until 2017 (Pitts et al., 2018)."
- P2, L44: The study by Tencé et al. (2022) is now mentioned in this section.
- P2, L54ff: A sentence was added L50ff with the purpose to explain the different scales. However, it has to be emphasized that 'hard' boundaries between types rarely exist.
- P3, L66: In this sentence the word "cloud" was replaced by "PSC".
- P3, L68: The sentence was rewritten: "Chemical reactions on the surfaces of PSC particles can then cause large-scale ozone depletion."
- P3, L78: We included three more recent references, one of them a publication in connection with the RECONCILE campaign.
- P4, L. 95ff: The numbers of measurement days and hours are discussed in the beginning of section 3. Here, we added a sentence to specifically point this out.
- P5, Sect. 3: Examples for warm and cold winters have been added. Winters 2014/15 (warm) and 2015/16 (cold) can be seen as examples how PSCs are more frequently present during a cold winter. Additionally, winters 2012/13 (warm) and 2013/14 (cold) are mentioned to show that the number of measurement opportunities for a ground-based lidar are strongly influenced by tropospheric conditions.
- P5, L135: We added some more explanation. Whether stratospheric conditions are favourable for the existence of PSCs depends on the prevailing temperature. During winter months the Danish Meteorological Institute compiles analyses and forecasts for the Arctic stratosphere based on ECMWF data. Those data are now compared with our measurement statistics. We are not aware of publications that specifically discuss the seasonal distribution of PSCs over Kiruna.
- P6, L149: We extended this part to include more reasoning why our classification scheme is similar to the one by Blum et al. (2005).
- P6, L164: It was not our intention to claim that $T_{NAT} < T_{STS}$. Relative to T_{ice} it is commonly assumed that T_{NAT} is appr. $7K$ higher (Hanson and Mauersberger, 1988), while T_{STS} is appr $4K$ higher (Carslaw et al., 1995). The statement was rewritten to avoid misunderstandings.

- P7, Figure 2 caption: NAT, STS and ice were added in parentheses.

- P8, Figure 4: We included an additional figure that shows plots with height distributions for each of the PSC types of our classification scheme. The new figure is Fig. 5.

- P9, Figure 5: This is Fig. 6 now. The legend was modified to include NAT, STS, and ice.

- P9, L198: It is very often implicitly assumed that reanalysis datasets like ERA5 provide a reasonably good description of the atmospheric state at a certain time and location. Comparisons with radiosondes (see e.g. Graham et al. (2019) and references therein) and, in the case of winds, with radar data (e.g. Sivan et al., 2021) appear to confirm this. Concerning our location, an additional investigation how ERA5 compares with measurements by radiosondes that sporadically are launched from Esrange (appr. 30 km from the location of our lidar) or with winds derived from the wind profiling radar at Esrange are beyond the scope of this study. We assume that the good representation of atmospheric conditions at other locations that ERA5 provides also is true for Kiruna.

- P11, L226: We believe that the larger heights of wave PSCs are due to adiabatic cooling as a result of lifting of air parcels in the wave motion. A similar phenomenon can be observed in tropospheric clouds in the lee of mountains.

- P11, L229 and L231: The part was rewritten. The purpose of this paragraph was (and is) to stress that we cannot detect in our data a trend over time, the reason being the high interannual variability of the Arctic polar vortex. A review of the current status of research on the impact of climate change on the stratosphere is not the aim of this study.

- P12, Figure 9: This is now Fig. 10. New figures were added, Figs. 11 and 12, that show the height distributions for the individual types of our PSC classification.

References

Blum, U., Fricke, K. H., Müller, K. P., Siebert, J., and Baumgarten, G.: Long-term lidar observations of polar stratospheric clouds at Esrange in northern Sweden, Tellus B, 57, 412–422, https://doi.org/10.3402/tellusb.v57i5.16562, 2005.

Carslaw, K. S., Clegg, S. L., and Brimblecombe, P.: A Thermodynamic Model of the System HCl-HNO3-H2SO4-H2O, Including Solubilities of HBr, from <200 to 328 K, J. Phys. Chem., 99, 11 557–11 574, https://doi.org/10.1021/j100029a039, 1995.

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