

Interactive comment on “Polar stratospheric cloud climatology based on CALIPSO spaceborne lidar measurements from 2006–2017” by Michael C. Pitts et al.

Anonymous Referee #2

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The manuscript presents a climatology of PSC observations acquired by the spaceborne CALIOP lidar instrument over more than ten years. In this new version of the dataset, the authors have significantly improved their PSC detection and classification schemes, especially with respect to the detection threshold and PSC composition boundaries. They have included confidence indices on the composition and an estimation of the random uncertainties of the optical quantities. As new parameters, derived PSC surface and volume densities have been added to the dataset.

The multi-year climatology is analysed with respect to the thermodynamic equilibrium state of the different PSC compositions. Further, the spatial and temporal evolution

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of PSCs in both hemispheres for different years has been described in detail. At the end, the CALIPSO observations are compared to satellite measurements which have been acquired during a ten-year period between 1979 and 1989 by the SAM II solar occultation instrument. It is concluded that within the limitations of this dataset no long-term changes can be observed.

This is a very important new dataset which will help to further progress our knowledge about polar stratospheric clouds and their involvement in stratospheric chemistry. The manuscript is well organized, clearly written and all Figures support the statements and conclusions drawn in the text. Only the enhanced classification of ice in the new dataset could be more clearly justified and the comparison with SAMII a bit expanded (see below). I strongly support publication of the manuscript after taking the specific comments below into consideration.

Specific comments:

P2, L20 ‘sedimentation of large NAT particles (Molleker et al., 2014)’

Please cite also the original paper(s) referring to the large NAT particles as reason for the denitrification.

P5, L16 ‘interpolated to the CALIOP PSC orbit grid using a weighted average of the two nearest MLS profiles’

How has this weighting been performed?

P5, L28 ‘The data are then corrected for molecular and ozone attenuation using the MERRA-2 molecular and ozone number density profiles’

Are the ozon profiles from MERRA-2 or those from the MLS retrievals? If MERRA, how strong does it affect the preprocessing if the ‘real’ (MLS) profiles would be used?

P6, L11:

Is the second equation really correct, or should it read: $\beta'_{\text{perp}} = \beta'_{\text{perp, meas}}$

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– beta'_par x CT ?

P6, L17 '[unc_par] ... [unc_perp]':

1. 'par' should everywhere be exchanged by 'para' not to confuse it with 'particles'
2. 'unc' is a strange variable. Could it not be called delta_beta', so that the direct connection with beta' becomes clear?

P7, L26 'is fixed at 10 cm⁻³':

Could you provide a reason for this value (e.g. a citation) and how large its variation could be?

P9, L21 'Points with CI_NS > 1 are presumed to be PSCs containing non-spherical particles.':

This seems to be a 2-sigma limit – could you describe more clearly what it means in percentage of the whole data points: how many of the 'non-spherical' particles might be spherical and vice-versa?

P9, L28 'detected through gas-phase uptake of HNO₃ as observed by MLS'

Regarding your analysis of volume-density later in the manuscript: can you confirm, that the amount of HNO₃ uptake seen by MLS is in accordance with the detection limit of CALIOP?

P12, L18 '8.3%'

In Fig. 10 the number seems 5.8% (?)

P12, L17..:

Apart from the referenced modelling work by Zhu et al., 2018, which additional arguments are there to support the strong increase in the detected ice-PSCs in v2 compared to v1?

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P13, L17..:

Is the explanation for the bimodal distribution of NAT-mixtures also confirmed by any modelling work which could be referenced here?

P14, L22 'persisting until early October':

From your Fig. 12, PSC are also often seen until mid and even end of October.

P14, L30..:

Is there any possibility to distinguish the PSCs from upper tropospheric cirrus (e.g. in terms of volume/surface density)? Do they 'separate' when plotting against potential temperature, if it is mainly caused by an upward displacement of isentropic surfaces, a separation might be possible.

P20, L10 'Then, we integrated the occurrence frequencies':

Does 'integrated' just mean 'summed up' ?

P20, L16: 'However, note that the SAM II occurrence frequencies are higher than those of CALIOP early in the PSC season.'

May this difference in the early PSC period also be caused by how the sightings in case of SAM II are counted? During this time, there is a clear maximum at around 18 km and a minimum below. As SAM II is a limb-sounder, the sightings below might be influenced by the higher PSCs through which the SAM II line-of-sight passes. Has this been taken into account in the comparison?

P20, L17: 'This may be a reflection of the greater sensitivity of the limb-viewing occultation measurements to the onset of PSCs when liquid droplets first began to deliquesce and/or when low number density NAT particles form that are below the CALIOP detection thresholds'

How far south are the soundings by SAM II in mid-May? Aren't the 'sub-visible' PSCs

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identified by MLS more in the centre of the vortex where SAM II has not been observing?

P22, L24 'The estimates assume liquid particles (binary H₂SO₄-H₂O or STS) only and thus have large uncertainties when NAT mixtures or ice are present'

It would be helpful for the reader to repeat at this point that in case of NAT or ice the values are very probably lower limits of surface and volume density.

P33, Fig. 3:

To better understand the differences between the new and the old composition classification, either the separation lines of v2 should be included in Fig. 3 or those of v1 in Fig. 4.

P33, Fig. 3, caption 'and symbol sizes are proportional to NAT'

Does 'size' mean the symbol area or the diameter?

P44, Fig. 14:

The colours are partly difficult to distinguish, could different symbols be used, at least for the case of similar colours?

P54, Fig. 24:

Please plot the results from both instruments in one graph. As it is now, the comparison in relation to the text is difficult.

Technical:

P2, L5: 'of season' -> 'of the season'

P6, L9,11: numbering of equations missing

P14, L20: 'Hence, it not' -> 'Hence, it is not'

P16, L17: 'from the near' -> 'from near'

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P17, L24: 'about the pole' -> 'around the pole'

P20, L6: delete blank between 'degree' and 'N' or 'S'

P21, L26: 'that more are more' -> 'that are more'

P32, Fig. 2 caption: 'in yellow': in Fig. 1 this appears more light green than yellow

P41, Fig. 11 caption: '1 Antarctic' -> '12 Antarctic' (?)

P43 and P49: color bar legend: '(x 10⁶ km²)' should read either '(10⁶ km²)' or '/(10⁶ km²)'

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