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Atmospheric Chemistry and Physics
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Discussions

Interactive comment on **"Comparison of Antarctic polar stratospheric cloud observations by ground-based and spaceborne lidars and relevance for Chemistry Climate Models"** *by* **Marcel Snels et al.**

Marcel Snels et al.

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The answers have been uploaded as a pdf file. See below. Answers to referee 1

Interactive comment on "Comparison of Antarctic polar stratospheric cloud observations by ground-based and spaceborne lidars and relevance for Chemistry Climate Models" by Marcel Snels et al.

Anonymous Referee #1

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Discussion paper

Received and published: 18 September 2018

A Review of “Comparison of Antarctic polar stratospheric cloud observations by ground-based and spaceborne lidars and relevance for Chemistry Climate Models” by M. Snels et al.

<General Comments>

This paper describes the comparison between PSC measurements at Antarctic McMurdo Station from ground based lidar and CALIOP satellite measurements. Furthermore, the paper tries to extend the comparison of PSC statistics from CALIOP with several CCM model results from CCMVal-2 and CCMI. Although scientific value of this study might be significant, the method of comparison especially with CCM models is not well organized to derive scientifically useful conclusions, as is pointed out below. Also, there are too many typos and careless mistakes in the draft. A major revision is required before this paper will be published in ACP. I recommend that authors should check the draft carefully, including the native check, before submitting the revised draft.

(M1) In Section 3.2, the authors try to compare the PSC statistics from 5 years (2006-2010) measurements by CALIOP, with the result of 4 CCM models from CCMVal-2, and one CCM model from CCMI. However, the model run type they chose for CCMVal-2 models are REF-B2, which are targeted to be used for future predictions until 2100. The major problem for this comparison is that the result of REF-B2 run contains both inaccuracy in modeled temperatures and imperfectess in PSC schemes which are different in each model. The combination of inaccuracies both in modeled temperature and PSC schemes makes it extremely difficult to understand the nature of PSC in each model. Rather than comparison with CCMVal-2 REF-B2 runs, it is strongly preferred to compare with CCMI outputs with refC1SD runs (which is available from http://badc.nerc.ac.uk/browse/badc/wcrp-ccmi/data/CCMI-1/output), which use nudging with more realistic temperature and wind field, just to test the PSC scheme in each model. Even if the authors stick to the comparison with CCMVal-2 model results, they should at least use the REF-B1 model run results, which are targeted to reproduce the past. In this case, the comparison with CALIOP could be made only for 2006, because REF-B1 run was made only for 1960-2006. Since CCMI refC1SD runs cover until 2010, I strongly recommend making comparisons with CCMI model outputs with CALIPSO Measurements. ANSWER: (M1) The indication of the REF-B2 run was a typing error, we apologize for that. In this manuscript we evaluate the REF-B1 simulations available for the period 1960–2006. As the reviewer highlights, those simulations were chosen because they have been constructed to include the interannual variabilities of the 11 year solar cycle, the QBO, Sea Surface Temperature (SST), volcanic effects, greenhouse gas (GHG) concentrations, and ozoneâĂŘdepleting substance (ODS) concentrations (Morgenstern et al., 2010). The SST and sea ice evolutions are prescribed using the HadISST1 (Rayner et al., 2003). The variations of the GHGs and the ODSs follow the IPCC SRES A1B scenario and WMOâĂŘadjusted scenario A1. To our opinion these free running simulations are the most suitable to be compared with the statistics from available observations.

(M2) In Section 3.1, the authors mention about more sophisticated.0/SD/CARMA model and EMAC/MSBM model, which use more realistic parameterizations for PSCs. It would gain the value of this paper significantly if they could include the comparison of CALIOP PSC statistics with the result of these models. ANSWER: The more sophisticated models are mentioned in the manuscript because those are, to our knowledge, the most significant advancements in the field of PSC representation in Global Climate Models used for the ozone and climate change studies. The CARMA model is an interactive aerosol and radiation model fully coupled to the WACCM, able to fully simulate advection, diffusion, sedimentation, deposition, coagulation, nucleation and condensational growth of atmospheric aerosols online with the temperature, dynamics and radiation structure simulated by the GCM. This approach is completely different from the parametrizations available in the simulations we are analysing here. A full evaluation of the WACCM/CARMA models in Specified Dynamics runs w.r.t. CALYPSO data are available in literature (in the Zhu et al cited works) and are outside the scope of this intercomparison (where we work with free running simulations). It would be certainly interesting to apply the diagnostics proposed within our analysis to a free-running set of simulations performed with models including interactive aerosols. This could be the objective of a future study, when a set of simulations from new generation models might be available.

M3) In each model, denitrification and dehydration are included as is shown in Table 3. This would change the vertical distribution of HNO_3 and H_2O, which would affect the threshold temperature of NAT and ice PSCs, i.e., T_NAT and T_ice. However, this effect is never mentioned or discussed in the manuscript. Moreover, in many places in the text (especially in Sections 2.6 and 3.4), it is not clearly stated which temperature (MERRA-2, NCEP, or derived T in CCM) is used, and how T_NAT and T_ice are calculated (using HNO_3 and H_2O value from MLS data, modeled value in CCM, or fixed values like 6 ppbv HNO_3 and 4.5 ppmv H_2O). The effect of denitrification/dehydration in modelled PSC should be discussed in the manuscript. ANSWER: First of all, we use MLS values for HNO3 and H2O concentrations, to calculate the formation temperature of NAT and ice. The temperatures used in this work are taken from MERRA-2. The temperatures used in the CCM models are generated by the models themselves, Tnat AND Tice have been calculated from the HNO3 and H2O taken from GOZCARDS

(M4) For a PSC classes comparison described in Table 1, although the percentage of each PSC class is similar, this does not prove that each one to one PSC is simultaneously observed both by ground-based lidar and by CALIOP. I would recommend authors to add the statistics showing one to one correspondence of comparison of PSC classes observed by tables like the attached tables. Table A shows the statistics when CALIOP measured specific class of PSC, what PSC was observed by McMurdo ground-based lidar, or no PSC was observed. Table B shows the statistics when ground-based lidar measured specific class of PSC, what PSC was observed by CALIOP, or no PSC was observed. ANSWER: It is not the goal of the article to make

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a point-to-point comparison for validation purposes. The goal is to verify if the ground-based measurement are representative for a larger area, typically contained in a 7x2 degrees box around McMurdo. Apart from that a point-to-point analysis presents the following difficulties: 1) None of the overpasses of CALIPSO are sampling the same air mass as the ground based lidar. To illustrate this I show a plot of all overpasses within the 7x2 degrees box, which corresponds roughly to a distance of 100 km from . McMurdo. While CALIOP provides a resolution of 5 km (when integration is required due to low signal-to-noise ratio up to 135 km !) the air mass sampled by the ground-based lidar extends to at most 100 m. (30 km * 3 mrad field of view of the telescope). Another important difference of the two lidars is that a CALIOP overpass occurs in about 30 seconds, while the ground-based data are integrated over 30 minutes. This implies that the ground-based measurement integrates air masses moving with a wind speed varying from 0 to 50 m/s, depending also on the altitude (the wind speed might be very different at 15, 20 and 25 km), rendering a comparison with an instantaneous profile of CALIOP very questionable. However, the statistical analysis is only meaningful if the sampling of the two lidars covers the same period of time and if this period of time has a dense coverage. In order to achieve this we concentrate on 2006, having a large number of observations by both lidars with a good coverage (see figure 1 of the manuscript). We then analyse the months July and August and report the statistics in terms of occurrences of PSC classes and dependence on altitude.

Differences and agreement have been discussed in the revised manuscript.

(M5) In Section 3.4, they discuss about the cold pole bias in most CCMVal-2 CCM models. However, when I read the SPARC report No.5 Chapter 4 “Section 4.3.5 Polar stratospheric cloud threshold temperatures” in page 128, there is an explanation that CCM models have warm bias and A_NAT and A_ice show low value compared with ERA-40 temperature. This description totally contradicts with the discussion described in Section 3.4. Please explain why such contradiction occurs.

ANSWER: Looking at figure 4.1 of the Sparc report (page 112) it is evident that all models have a cold temperature bias except for the two UMUKCA models. This is explicitly stated on page 113. Figure 4.15 in “Section 4.3.5 Polar stratospheric cloud threshold temperatures” in page 128, shows that the same two models strongly underestimate the mean PSC Area’s which is of course in agreement with the warm bias of these models discussed before. So there is no contradiction.

All the corrections suggested by the referee below have been made.

ïČij (S1) The numbers in author list are not ordered correctly, i.e., 1, 5, 2, 3, 4. It should be

ïČij 1, 2, 3, 4, 5.

ïČij (S2) P1, L3: The abbreviation of CALIOP should be shown also in the abstract.

ïČij (S3) P1, L9: The meaning of “... and a selection simulations obtained ...” is unclear.

ïČij (S4) P1, L4: In Pitts et al. (2018, ACP), they use “v2” instead of “V2”. Please check if

ïČij V2 should be changed to v2 throughout the manuscript or not.

ïČij (S5) P1, L18: The abbreviation of WACCM-CCMI should be shown.

ïČij (S6) P2, L7: The abbreviation of CALIOP should be shown here, not at P2, L20.

ïČij (S7) P2, L18: Chemistry Climate Models –> Chemistry Climate Models (CCMs)

ïČij (S8) P2, L20: clouds and aerosol –> clouds and aerosols

ïČij (S9) P2, L26: Chemistry Climate Models –> CCMs

ïČij (S10) P2, L29: The SPARC Report No5 (2010) cannot be found in the reference list.

ïČij (S11) P2, L30: Chemistry Climate Models –> CCMs

ïČij (S12) P3, L1: Chemistry Climate Models (CCM) –> CCMs

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ïČij (S13) P3, L14: CALIOP (Cloud Aerosol Lidar with Orthogonal Polarization) –> CALIOP

ïČij (S14) P3, L14: Details on CALIOP –> Details of CALIOP

ïČij (S15) P4, L16: Reference (Cairo et al., 1999) should appear at the end of Line 18.

ïČij (S16) P5, L14: CALIPSO V2.0 data –> CALIPSO v2 data

ïČij (S17) P5, L15: V2.0 –> v2

ïČij (S18) P5, L17: V1.0 and V2.0 –> v1 and v2

Please also note the supplement to this comment:
https://www.atmos-chem-phys-discuss.net/acp-2018-589/acp-2018-589-AC1-supplement.pdf

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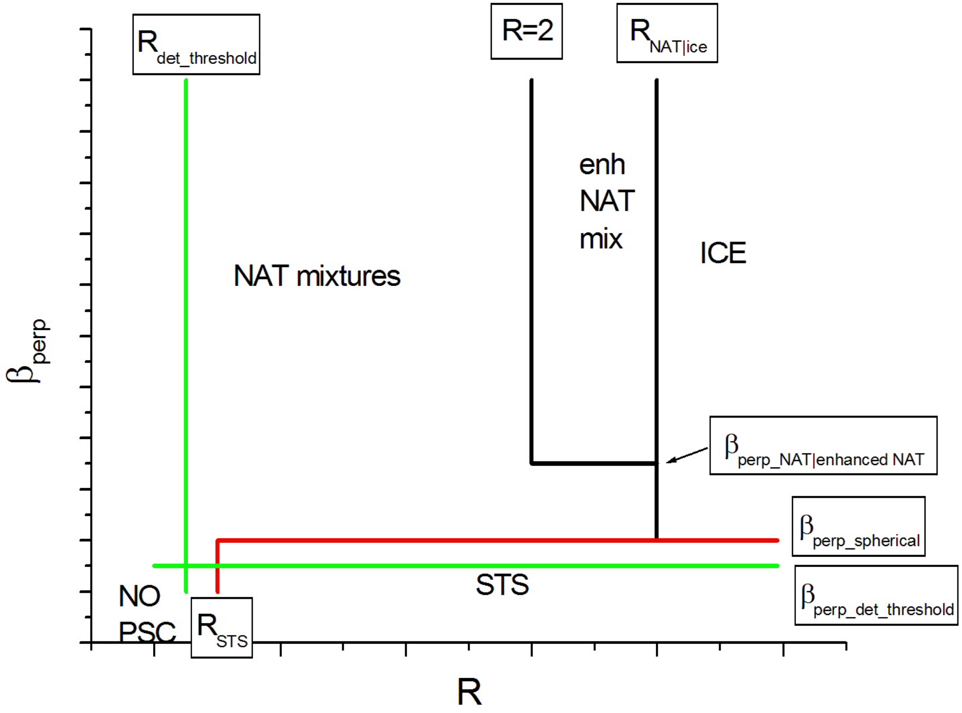
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R=2
$R_{NAT|ice}$
enh NAT mix
ICE
NAT mixtures
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STS
NO PSC
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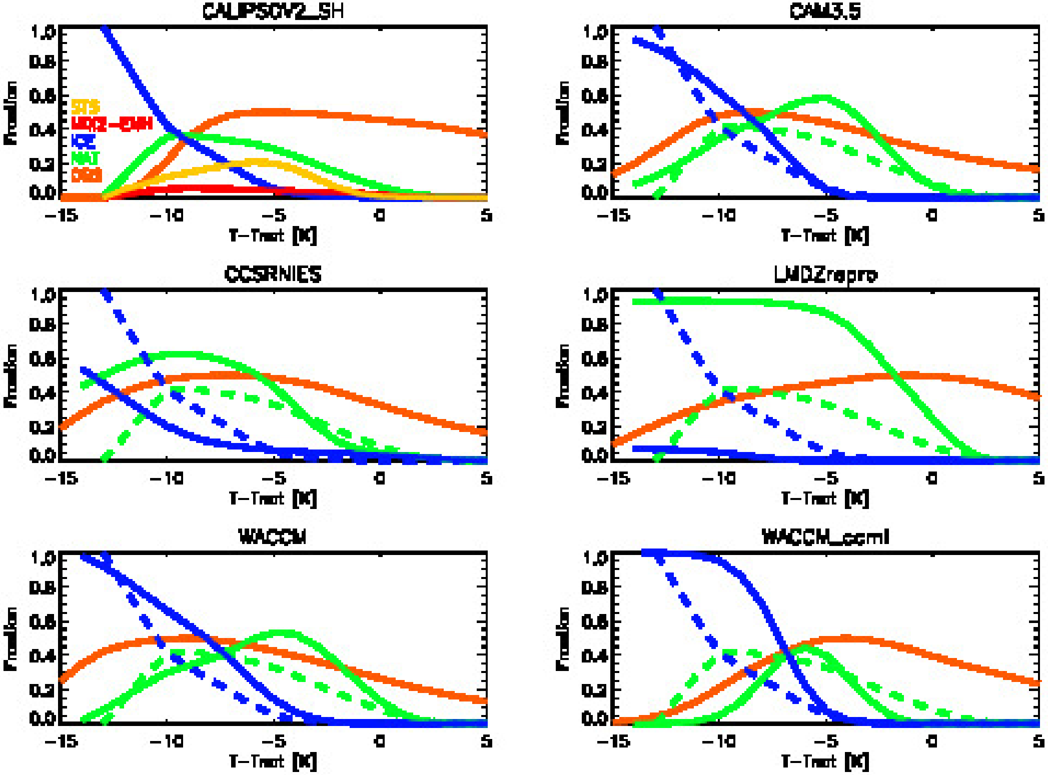
R

Fig. 1.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CAM3.5
CCSRNIES
LMDZrepro
WACCM
WACCM_ccmi
Fraction
T–Tnat [K]
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0.8
0.6
0.4
0.2
0.0
–15
–10
–5
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5
STS
MIX2–ENH
ICE
NAT
OBS

Fig. 2.

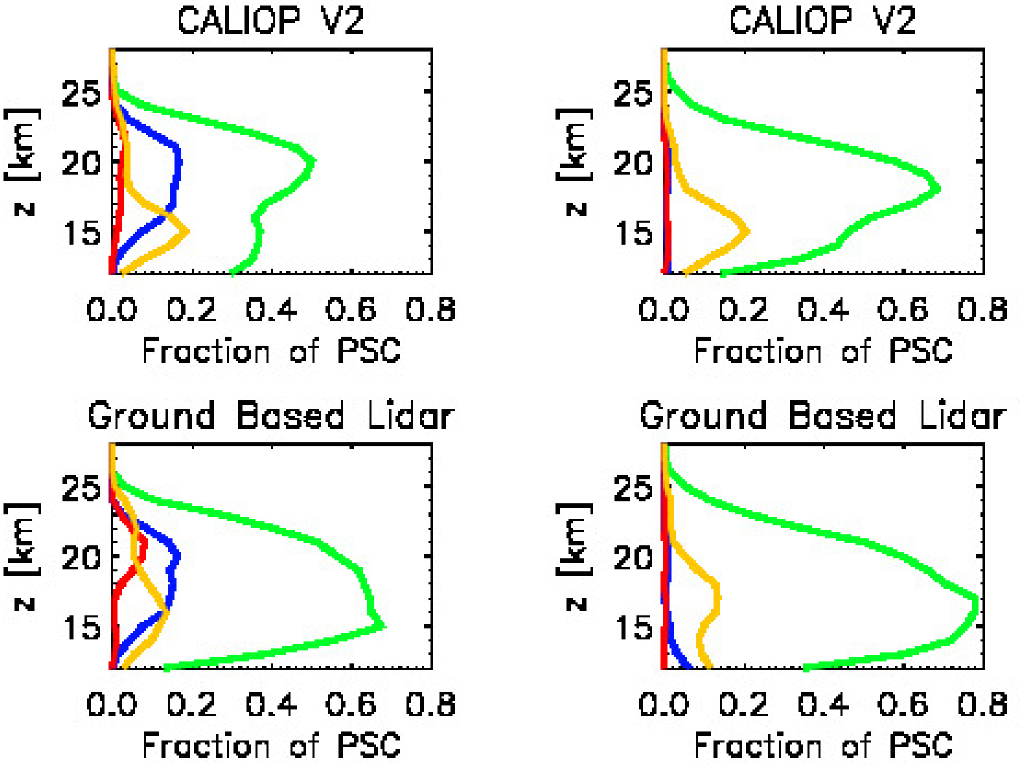

Fig. 3.

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