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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observations and analysis of polar stratospheric clouds detected by POAM III and SAGE III during the SOLVE II/VINTERSOL campaign in the 2002/2003 Northern Hemisphere winter" *by* J. Alfred et al.

Anonymous Referee #2

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Interactive Comment on "Observations and analysis of polar stratospheric clouds detected by POAM III and SAGE III during the SOLVE II / VINTERSOL campaign in the 2002/2003 Northern Hemisphere winter" by J. Alfred et al.

Summary of paper ——————-

This study presents an analysis of remotely-sensed observations of polar stratospheric clouds from the 2002/3 Northern Hemisphere winter made by the SAGE III and POAM III instruments aboard the METEOR-3M and SPOT 4 polar-orbiting satellites (respec-

tively).

The paper generates an important combined SAGE-POAM PSC dataset to give a wide coverage of the vortex over the winter. Careful calibration of the two datasets is carried out to ensure consistency of background aerosol extinction.

The number of profiles which detected PSCs is reported for the two satellite instruments as well as the change in occurence frequency of solid (type 1a) PSCs and liquid (type 1b) PSCs over periods of the 2002/3 Arctic winter.

The main result of the paper however, concerns the relationship between a derived PSC observation frequency, (calculated using an automated PSC detection algorithm) and the temperature relative to the saturation temperature for nitric acid tri-hydrate (NAT) particles. Note that for these purposes, TNAT is calculated using a nitric acid profile prior to denitrification.

It is found that early in the winter, PSCs are detected at temperatures near TNAT whilst later in the winter, temperatures are required to be several degrees below TNAT before PSCs are observed.

This shift in derived PSC occurence temperature is attributed to the sedimentation of large nitric acid containing PSCs (denitrification) reducing the nitric acid concentration, hence also reducing the NAT saturation temperature (below its non-denitrified value).

The authors go on to infer that denitrification of 80% must have occurred to explain the oberved shift in PSC occurence temperature.

General comments ————————-

The paper addresses an important topic as the temperature at which polar stratopsheric clouds exist and the extent of stratospheric denitrification caused by sedimenting PSCs are both critical to understanding the extent of ozone loss in the polar stratosphere. The combined SAGE-POAM dataset is also of importance for models to help evaluate our understanding of these processes.

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The paper is interesting and the reader is taken through the results in a well-structured way. In general the paper is fairly well-written, although section 4.1 (pages 11405,6) and would benefit from some re-writing (see specific comments). Also the terminology of "PSC occurrence temperature" is sometimes described as "PSC formation temperature" which should be avoided as it implies that it is related in some way to the nucleation mechanism. Overall the paper is worthy of addition to ACP once the comments have been addressed.

I agree however with Referee 1 that the limitations of the method for deriving the extent of denitrification should be clearly stated. The discrepancies between the other observations should also be explored in more detail in light of these limitations.

Specific Comments ——————–

Page 11392 line 16 (Abstract) Suggest inserting "(using a nitric acid profile prior to denitrification)" after "NAT saturation point".

Section 1: introduction

Since the main focus of the paper is to look at the shift in PSC occurrence temperatures, a brief description of the various types of PSCs should be included and also the various nucleation mechanisms responsible for their production and temperatures at which they form with references.

Also, since the paper is inferring a value of denitrification, the motivation for understanding denitrification should be more clearly stated with regard to prolonging chlorine activation and thus enhancing polar ozone loss. The introduction should also be expanded to include a summary of other studies which present observed and modelled denitrification for the 2002/3 winter (Grooss et al 2005; Davies et al, 2006) and it should be set in the context of that which occurred in other Arctic winters (see Davies et al, 2005; Mann et al, 2003).

Section 3.1

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Page 11397 line 15: the authors use a 3-sigma value for the threshold when using the Fromm et al (2003) Unified detection algorithm. The Fromm paper suggests using a 6-sigma value to be sure that a PSC is detected and a 3-sigma for a less definite detection. Please explain why the 3-sigma threshold is used.

Page 11398 line 4: the authors mention "aerosol cleansing inside the vortex". Please explain.

Section 3.2

Page 11399 line 3: be more specific than "about the same temperature very near TNAT" — from the Figure it seems to be around TNAT +/-3K.

Page 11399 line 26: presumably in Figure 6 the SAGE profile has been corrected — if so please state.

Page 11400 line 8: rather than stating that both instruments see a PSC from 460 to 575K, be more specific and state that the algorithm gives POAM detecting a PSC between 460 and 570K and SAGE detecting one between 480 and 590K. Thickness is the same (110K) in both but 20K offset.

Page 11401 line 10: It is not mentioned that there is a signal of around 15% at -2<T-TNAT<0 in the SAGE statistics in Figure 7. Is this of physical significance?

Page 11402 line 27: state the extent of the MkIV observed denitrification (˜4 ppbv at 550K) at 550K.

End of Page 11402 :Also state the derived denitrification observed by MIPAS-E — around 6 ppbv by end of December at 505K for equivalent latitude ˜ 75 degrees (see Davies et al 2005).

End of Page 11402 : Also note in text that in Figure 8 there are regions 500K-600K where T<TNAT but no PSCs observed — presumbly this is also due to denitrification removing nitric acid and hence reducing TNAT below its value in non-denitrified

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conditions?

Section 3.3

Page 11403

In Table 1, the composition is shown for the periods Dec 1-10, Dec 21-30 and Jan 1-10. Why is the period December 11-20 omitted — this was a period with considerable PSCs. The authors should ideally include this period or if there is a good reason for omitting it state it. Also include this period in the other similar tables later in the paper.

In section 3.3, possible causes for the increase in Type 1b PSCs compared with Type 1a PSCs should be included. Is this just a reflection of a lower temperature regime? Also the impact on PSC observation freqency and occurrence temperature of a change in PSC composition should be clearly explained here.

Section 4.1

Page 11404: lines 19-30 — It would be better to refer to potential temperature intervals ratjer than potential temperature bins and similarly better to refer to time periods than time bins.

Page 11405: line 7 — the authors should clearly define what is meant by "PSC occurrence temperature". The technique by which it is calculated is described but since the authors are not trying to equate this with the temperature at which the particles were nucleated, why is the term "PSC formation temperature" used here? I would recommend solely using the term "PSC occurrence temperature" to avoid confusion.

Page 11405: line 11 — insert i), ii) and iii) before the 3 alternative possibilities for the shift in PSC occurrence temperature.

Pages 11405–11407 This section is rather difficult to read as it is just one big block of text. Suggest putting subsections in as 4.1.1. Change in PSC composition, 4.1.2 Possible biases in Met Office temperatures, 4.1.3 Dehydration etc.

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Page 11405: line 15-26 — this section is rather unclear. Presumably by the phrase "4K decrease in Type 1B PSC formation temperature relative to Type 1A formation temperature", the authors mean "difference" rather than "decrease" and are they referring to a difference between TNAT and TSTS (the temperature below which Type 1b PSCs are observed). This should be written more clearly.

Page 11405 line 26 – page 11406 line 8 This section should be more succinctly — e.g. "This is an upper limit estimate" is not required if the start of the sentence at line 1 on page 11407 was rephrased. Please re-write.

Page 11406 line 17 – after "temperatures become biased warm" put in the text the approximate extent of the change in the biases as shown in Table 2 (i.e from -0.3 to +0.9K at 50 hPa).

Page 11407 Why have the in-situ measurements of water vapour made by the FISH instrument aboard the Geophysica not been mentioned? I understand that no significant dehydration was observed during the denitrification flights. Please state this also to add to the evidence of no dehydration.

Section 4.2 The comparison with other studies should also take in the denitrification inferred from the MIPAS-E nitric acid observations and the DLAPSE model simulations (Davies et al, 2005) which found maximum denitrification of 80% in the core of the vortex by early January 2003.

Table 1 caption – State that the percentages shown are for the combined SAGE-POAM dataset.

Table 3 caption — Briefly describe how the PSC occurrence temperature is calculated.

Typos etc. ———-

Page 11392 line 10 (Abstract) insert "from 15th January" after "either instruement"

Page 11392 line 11 (Abstract) insert "from then only" before "sparingly"

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Page 11400 line 20 repace "simply" with "as".

Page 11401 line 5 replace "It should be noted that" with "Note that"

Page 11402 line 14 delete "the" between "below" and "TNAT".

Page 11402 line 14 replace "tend" with "tending"

Page 11403 line 25 remove "the" between "for" and "HNO3"

Page 11425,6 Figure 8,9 — please insert a) and b) in caption and next to Figures as referred to in text.

Page 11426 Figure 9 caption – remove "The data were binned in 2 separate potential temperature bins as indicated" and insert at end of 1st sentence in caption "for potential temperature ranges a) 475-550K, b) 400-475K."

Page 11426 Figure 9 caption – remove sentences beginning "There is a clear shift..." and "The magnitude of the shifts..." — this sort of description of the results should only be in the text not the caption.

References ———-

3-D microphysical model studies of Arctic denitrification: comparison with observations Davies, S. et al, Atmos. Chem. Phys., Vol. 5, pp 3093-3109, 2005.

Testing our understanding of Arctic denitrification using MIPAS-E satellite measurements in winter 2002/2003 Davies, S. et al, Atmos. Chem. Phys., Vol. 6, pp 3149-3161, 2006.

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Factors controlling Arctic denitrification in cold winters of the 1990s Mann, G. W. et al, Atmos. Chem. Phys., Vol. 3, pp 403-416, 2003.

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