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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Differences in Arctic and Antarctic PSC occurrenceas observed by lidar in Ny-Ålesund (79° N, 12° E) and McMurdo(78° S, 167° E)" *by* M. Müller et al.

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We thank Reviewer #1 for his/her constructive comments and useful suggestions.

General Comments: Apparently both reviewers found particular interest in the few information on the PSC type Ia enhanced observations, while to us they are a minor point in the context of this study. Since we intend to emphasize on the differences in the occurrence of solid and liquid PSCs, it seems less important to us to distinguish between NAT clouds with different particle size and numbers. We therefore decided to withdraw the naming of PSC types Ia, Ia enhanced, and Ib, and rather talk about NAT and liquid clouds, respectively. Detailed information on the observation of type Ia enhanced PSCs in McMurdo and Ny-Ålesund can be found in the climatological studies by Adriani et al. (2004) and Massoli et al. (manuscript submitted to JGR, 2005), respectively.

Please find below our detailed answer to the specific comments.

Specific Comments:

1) We have changed "constant background of NAT particles" to "persistent background of NAT particles" throughout the manuscript.

2) In a comparison of different meteorological datasets for the southern hemisphere, Manney et al. (2005) show that the temperature difference below 30 hPa between ECMWF and NCEP/CPC analyses is less than 1 K. The McMurdo lidar evaluation implements the atmospheric density as retrieved from NCEP/CPC temperatures. Possible temperature deviations in the order of 1 K would not affect the general results in lidar backscatter ratio. Accepting an irrelevant discontinuity, we present the monthly mean temperature profiles from ECMWF for reasons of accessibility.

3) For the Antarctic TNAT and TIce lines in Figure 2, we have now averaged typical stratospheric Antarctic H2O values from Nedoluha et al. (2000), thus using 5ppmv in June and July, 3 ppmv in August, and 2 ppmv in September to account for dehydration effects. To represent denitrification, we now apply HNO3 values that are geared to MLS observations presented by Santee et al. (1999), thus using 8 ppbv in June, 4 ppbv in July, and 2 ppbv in August and September.

4 / 5 / 6) We are aware that each dataset of ground-based stratospheric lidar measurements may have a bias due to the techniques' limitation by tropospheric cloud cover. Although we cannot prove it by additional material, we think that lidar measurements represent the general picture of PSC occurrence above each station in an appropriate way. The suggestion to compare the presented monthly mean temperature profiles with those including only the days when the lidar was operated may not have the de-

sired effect of demonstrating the representativeness of our measurements, but might result in large differences for some months since e.g. the Ny-Ålesund lidar system is not necessarily operated during minor / major stratospheric midwinter warming periods. In any case, comparing lidar measurements from Ny-Ålesund and McMurdo, we assume that a possible systematic bias caused by cloud cover would affect both datasets. Indeed more important is the fact that the analysed datasets of the two stations are comparable in terms of synoptic and mesoscale PSC occurrence percentage. The vertical variability of the observed PSCs is supposed to reflect the scale of the temperature field causing their formation, with large scale vertical variability found for synoptic scale PSCs and small scale vertical variability caused by mesoscale effects (Adriani et al, 2004). The climatological studies by Adriani et al. (2004) and Massoli et al. (manuscript submitted to J. Geophys. Res.) show similar percentages for the PSCs at McMurdo and Ny-Ålesund, with 60% and 55% of the PSCs showing large scale variability, respectively. We therefore assume that it is adequate to compare the two datasets even if they are not suitable to represent the overall hemispheric situation, respectively. An obvious difference between the Ny-Ålesund and McMurdo lidar operation is the daily measurement duration, but since the stratospheric meteorological situation in general is relatively stationary over a day, each lidar profile may be taken as representative for the day. In the revised manuscript, we added a paragraph discussing these points together with a detailed description of our method to count PSC events and the resulting comparability of the two datasets.

7) Other PSC climatologies -especially when restricted to volcanic aerosol free conditions- are found sparsely in literature, and to our knowledge the general difference in PSC type occurrence between the Arctic and Antarctic has not been addressed earlier. Poole and Pitts (1994) presented a 10-year climatology of PSC observations from SAMII, describing the PSC sighting probability according to temporal and spatial behaviour, They find effects of denitrification in the Antarctic September observations, and also state the longitudinal dependence of Arctic PSCs due to the vortex shift. Although they admit the existence of different PSC types, those are not individuated

from the satellite sightings. Since our interhemispheric comparison is motivated by the occurrence of different PSC types observed by lidar, the necessary link to compare our lidar data with the Poole and Pitts (1994) satellite observations is missing. In a broader sense, consistency with the Poole and Pitts (1994) PSC climatology is affirmed, as the McMurdo and Ny-Ålesund datasets reveal generally the same temporal and spatial PSC behaviour when looking at the total observations (as shown by Adriani et al., 2004, for the McMurdo dataset, and by Massoli et al., manuscript submitted to JGR, for the Ny-Ålesund dataset). Other satellite-based PSC climatologies (e.g. Fromm et al., 1997; Fromm et al., 1999) also investigate PSC probability and the spatial and temporal PSC occurrence, but again it seems inappropriate to search for consistency with such different datasets. The percentage of PSC types observed in by lidar Ny-Ålesund as presented by Biele et al. (2001) differs from the numbers we find in our analysis due to several factors. First of all, Biele et al. (2001) used the lidar data of only 3 winters, including 1994/1995 that may still have been influenced by the Pinatubo aerosol. Furthermore, the analysis was based on 1 hour integrated profiles, and PSC signals were counted on all height steps of each profile, giving more weight to PSCs that have been measured for several hours on the same day and that have occurred over a wider vertical space. In our analysis, we avoid the lidar operation dependent weighting by counting PSC events only per day. Other PSC climatologies inferred from lidar data generally exhibit different behaviour in PSC type occurrence as the ground-based instruments are installed in geographical regions that may have a different position relative to the polar vortex (e.g. Dumont D'Urville in the Antarctic, or Thule in the Arctic). Obviously for the Ny-Ålesund data we find another PSC type distribution as e.g. long-term lidar observations from Andøya, Kiruna, and Sodankylä, since there PSCs are influenced by orographic gravity waves induced at the Scandinavian mountain ridge. Since from the presented analysis it is not possible to demonstrate consistency with other datasets, we refer to the recent PSC climatologies of the two stations (Adriani et al., 2004; Massoli et al., manuscript submitted to JGR, 2005) to pronounce the representativeness of the McMurdo and Ny-Alesund lidar datasets.

8) Biele et al. (2001) have been showing that the discrimination of parallel-polarized and perpendicular-polarized backscatter allows to identify the presence of solid particles inside a liquid cloud. This identification is based on the fact that both solid and liquid particles give a backscatter signal in the parallel-polarized channel, while only the solid and thus presumably non-spherical particles do give an additional backscatter signal in the perpendicular channel.

So on one hand, for a cloud consisting of mostly liquid particles, there will be a relatively large backscatter signal in the parallel channel with backscatter in the perpendicular channel only occurring if some solid particles are present. In the Ny-Ålesund dataset, the liquid clouds provide the largest number of all PSC events. By applying the Biele et al. (2001) analysis method, it would be possible to estimate how many of these liquid clouds also contain a small fraction of solid particles. Yet, in any case, the liquid particles are the most abundant volume in all of these clouds. Since this is the relevant parameter for the presented study, we did not split the analysis to parallel and perpendicular backscatter here. On the other hand, for a cloud consisting of mostly solid particles as most frequently found in the McMurdo dataset, there will be a backscatter signal both in the parallel and perpendicular channel. Unfortunately, there is no way to determine a possible fraction of liquid particles from the strength of the parallel backscatter, and the Biele et al. (2001) method does not succeed in this direction. Since it is not possible to determine the quantitative effect of a small fraction of solid particles in a mostly liquid cloud or of a small fraction of liquid particles in a mostly solid cloud, we remain with the historical lidar PSC classification method using the total backscatter ratio. As Figure 9 seems to be misleading rather than to add valuable information to the discussion, we decided to withdraw it from the revised version.

Technical Corrections The technical corrections have all been applied in the revised version.

References:

Adriani, A., P. Massoli, G. Di Donfrancesco, F. Cairo, M. L. Moriconi, and M. Snels: Climatology of polar stratospheric clouds based on lidar observations from 1993 to 2001 over McMurdo Station, Antarctica. J. Geophys. Res., 109, doi:10.1029/2004JD004800, 2004.

Biele, J., A. Tsias, B. P. Luo, K. S. Carslaw, R. Neuber, G. Beyerle, and T. Peter: Non?equilibrium coexistence of solid and liquid particles in Arctic stratospheric clouds. J. Geophys. Res., 106, 22991-23007, 2001.

Fromm, M. D., J. D. Lumpe, R. M. Bevilacqua, E. P. Shettle, J. Hornstein, S. T. Massie, and K. H. Fricke: Observations of Antarctic polar stratospheric clouds by POAM II: 1994-1996. J. Geophys. Res., 102, 23659-23672, 1997.

Fromm, M. D., R. M. Bevilacqua, J. Hornstein, E. P. Shettle, K. Hoppel, and J. D. Lumpe: An analysis of polar ozone and aerosol measurement (POAM) II Arctic polar stratospheric cloud observations , 1993-1996. J. Geophys. Res., 104, 24341-24357, 1999.

Manney, G. L., et al.: Diagnostic comparison of meteorological analyses during the 2002 Antarctic winter. Monthly Weather Review, in press, 2005.

Massoli, P., M. Müller, R. Neuber: Climatology of Arctic PSCs as measured by lidar in Ny-Ålesund, Spitsbergen [78°N, 12°E]. J. Geophys. Res., submitted, 2005.

Nedoluha, G. E., R. M. Bevilacqua, K. W. Hoppel, M. Daehler, E. P. Shettle, J. H. Hornstein, M. D. Fromm, J. D. Lumpe, and J. E. Rosenfield: POAM III measurements of dehydration in the Antarctic lower stratosphere. Geophys. Res. Let., 27, 1683-1686, 2000.

Poole, L. R., and M. C. Pitts: Polar stratospheric cloud climatology based on Stratospheric Aerosol Measurement II observations from 1978 to 1989. J. Geophys. Res., 99, 13083-13089, 1994.

Santee, M. L., G. L. Manney, L. Froidevaux, W. G. Read, and J. W. Waters: Six years of

ACPD

4, S3856–S3862, 2004

Interactive Comment

UARS Microwave Limb Sounder HNO3 observations: Seasonal, interhemispheric, and interannual variations in the lower stratosphere. J. Geophys. Res., 104, 8225-8246, 1999.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 6837, 2004.

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4, S3856–S3862, 2004

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