Reply to Anonymous Referee #2

We thank reviewer#2 for the helpful and detailed comments. We incorporated all minor correction and comments. More detailed revisions are stated below.

The newly developed MIPAS PSC database should provide an excellent resource as it is over a decade in length. However, no indication is given as to when/whether the database will be made available to the scientific community.

At the end of the summary section we are now highlighting this point in more detail. A companion paper on the MIPAS PSC climatology for Atm. Chem. and Phys. is in preparation and will include details how to access the data.

The complete measurement period of MIPAS has been processed with the new classification method, and currently a complementary manuscript is in preparation about the climatological aspects of the dataset. Therein, details will be given how the scientific community can access the dataset. The MIPAS PSC type dataset will be also part of a new activity on PSCs under Stratosphere-troposphere Processes and their role in Climate (SPARC). Main objectives of the activity are to compare remote and in situ datasets to identify their strengths and limitations, identify the key PSC characteristics required by global models and available from measurements, and to synthesize the new datasets into a state of the art PSC climatology (SPARC, 2016).

P1 L26: we can assume that CALIOP is not perfect wrt ice classification either.

Correct, but we show that MIPAS may overestimate the presence of ice and just changed the introduction sentence to*: Discrepancies are observed between the CALIOP and the MIPAS ice class.*

P3 L3: More recent instruments e.g. SAGE-III, SciSat ACE are able to discriminate
PSC types

Correct, we rephrased this sentence:

Although solar occultation measurements have some capability for the discrimination of PSC types (e.g. Strawa et al., 2002, Zasetsky et al., 2007), they cannot be conducted in the polar night.

P4 L13: Just to clarify, 1.2 cm-1 is not the ILS of MIPAS, which is 20 times better than this. The plots shows a MIPAS spectrum recorded at higher resolution (needed for gas species retrievals) but here smoothed with a Gaussian function convolution to remove sharp features. The NAT signature (several cm-1) is hardly "sharp", you might say "narrow" though.

Correct, we changed ‘sharp‘ to ‘narrow’.

P4 L23: Why aren’t the sensitivities compared for the same kind of averaging volume
i.e. by smoothing CALIOP to the resolution of MIPAS.

At this point we only like to refer to quantities already presented in the literature. A direct comparison on the PSC detection sensitivities of both instruments is not straight forward. A more detailed comparison on the detection sensitivities is presented in section 4.3.1, where we show that CALIOP and MIPAS are sensitive to different physical cloud parameters, depending on the particle type and describes in detail how to compare the sensitivities.

P5 Table 1: Thin horizontal line is missing between NAT and STS. Remove the pointless replication of table entries. e.g. volume densities are all the same for NAT and STS, and the mean radius values are the same for STS. [um] should be below "Mean Radius". "Cloud minimum bottom height" is better rendered as "cloud base" in the text.

We improved Table 1 in terms of the reviewer comments.

P9 Fig2: Does extinction vs wavenumber (with example for small and large particles) help to explain choice of wavenumber regions better than the RI alone?

Depending on the particle type the refractive indices show an even more pronounced typical wavelength dependency (gradients, peak structure) than extinction coefficients. Therefore we decided to use refractive indices instead for example extinction spectra. In addition, in the RTM calculation, which are rather time consuming due to scattering effects, we used only selected wavelength regions, but in the figure we like to illustrate the full wavelength range of interest.

P10 L9-10: What about the NAT particle shape? This applies to spherical particles (Mie theory) what about non-spherical shape effects on the NAT spectral peak?

A similar point with respect to ice was raised by reviewer#3. Therefore we included following paragraph in Sec. 2.2:

T-Matrix calculations with realistic bulk properties for cirrus clouds show that the scattering properties in the size range of PSC ice particles (effective radius < 10 µm) can be well approximated by Mie calculations and the influence of non-spherical particle shapes is negligible (Baran et al., 2003, Young et al., 2005). For NAT clouds Woiwode et al. (2014) found in balloon based IR measurements indications that aspherical particles might modify the spectral shape of the characteristic spectral NAT feature at 820 cm^{-1} (Fig. 1). This very recent finding has been investigated in more detail in a parallel study (Woiwode et al., 2016) and is not considered below.

P14 L13: The gradient reversal for sulfate and NAT/ice in the infrared near 7-8 um has been long established and exploited previously for limb measurements e.g. Taylor et al, 1994, J. Atmos. Sci., 51, 3019–3026. Corresponding wavelengths found in the MIPAS study are 8.16um and 7.1um near the peak and trough of the STS absorption curve, see Taylor et al Fig 7.

We incorporated in the revised version the reference and noted the similar wavelength regions in Taylor et al.:

Taylor et al. (1994) exploited the different gradients in the extinction spectrum of sulphate and NAT in the 1400 and 1200 cm^{-1} region for aerosol and PSC measurements of the Improved Stratospheric and Mesospheric Sounder (ISAMS) on the Upper Atmospheric Research Satellite (UARS).

Acronym Area... I found the labeling of Figs 3, 5, 7, 8 and reference to Table 2 extremely confusing ... Please simplify all of this. Just use the same names in the figures and the table. I wasn't able to keep track of the changing names as I switched pages between the figures and the table, so eventually I labeled the regions numerically (1) to (13) in these four figures to correspond directly with Table 2. I suggest you do the same in the revision of the manuscript. Also in Table 2 I added the corresponding Figure number in the "Classifier" column.

We followed the suggestion of the reviewer and labeled now the different classification areas with region (1) to region (13) and improved the corresponding Table 2.

P18 L18: Could this be improved optimally? What is the sensitivity to the ad hoc settings?

We investigated the sensitivity in a Monte Carlo simulation in section 3.4.

P21 L13: This is not detection. i.e. is there a cloud or not? This is classification. i.e. what type of cloud is it. If r<3um then a NAT cloud can be classified as NAT, otherwise it will not have the unique NAT classification but will still be detected as a cloud above threshold.

We agree and changed the term 'detection' to 'classification'.

P30 Table 3: Too many significant figures used, can round most of these with no loss of real information.

We agree, the number of digits are now reduced.

Please do something to improve the presentation quality of the figures. Some of the plots could really do with a serious tidy-up to remove "junk" in titles and labels that don't mean much to the reader. …

We followed the suggestions and reduced redundant information in all figures with MIPAS data, In addition we followed where possible the suggestion of reviewer#1 to present in the MIPAS PDFs figures the same year/month of MIPAS data in each discrimination methods.

New additional References:

Baran, A.J.: On the scattering and absorption properties of cirrus cloud, Journal of Quantitative Spectroscopy and Radiative Transfer, Volume 89, Issues 1-4, 17-36, doi:10.1016/j.jqsrt.2004.05.008, 2004.

CALIPSO Science Team: CALIPSO/CALIOP Level 2, Polar Stratospheric Cloud Data, version 1.00, Hampton, VA, USA: NASA Atmospheric Science Data Center (ASDC), accessed in July 2015, doi:10.5067/CALIOP/CALIPSO/ CAL_LID_L2_PSCMask-Prov-V1-00_L2-001.00, at https://eosweb.larc.nasa.gov/project/calipso/cal_lid_l2_pscmask-prov-v1-00_table, 2015.

Griessbach, S., Hoffmann, L., Spang, R., and Riese, M.: Volcanic ash detection with infrared limb sounding: MIPAS observations and radiative transfer simulations, Atmos. Meas. Tech., 7, 1487-1507, doi:10.5194/amt-7-1487-2014, 2014.

Hollstein, A., Fischer, J., Carbajal Henken, C., and Preusker, R.: Bayesian cloud detection for MERIS, AATSR, and their combination, Atmos. Meas. Tech., 8, 1757-1771, doi:10.5194/amt-8-1757-2015, 2015.

SPARC, Stratosphere-troposphere Processes And their Role in Climate: Polar Stratospheric Cloud Activity, http://www.sparc-climate.org/activities/polar-stratospheric-clouds/, latest access Feb 21st, 2016.

Strawa, A. W., Drdla, K., Fromm, M., Pueschel, R. F. Hoppel, K. W., Browell, E. V., Hamill, P., and Dempsey, D. P.: Discriminating Types Ia and Ib polar stratospheric clouds in POAM satellite data, J. Geophys. Res., 107(D20), 8291, doi:10.1029/2001JD000458, 2002.

Woiwode, W., Grooß, J.-U., Oelhaf, H., Molleker, S., Borrmann, S., Ebersoldt, A., Frey, W., Gulde, T., Khaykin, S., Maucher, G., Piesch, C., and Orphal, J.: Denitrification by large NAT particles: the impact of reduced settling velocities and hints on particle characteristics, Atmos. Chem. Phys., 14, 11525-11544, doi:10.5194/acp-14-11525-2014, 2014.

Woiwode, W., Höpfner, M., Bi, L., Pitts, M. C., Poole, L. R., Oelhaf, H., Molleker, S., Borrmann, S., Klingebiel, M., Belyaev, G., Ebersoldt, A., Griessbach, S., Grooß, J.-U., Gulde, T., Krämer, M., Maucher, G., Piesch, C., Rolf, C., Sartorius, C., Spang, R., and Orphal, J.: Spectroscopic evidence for large aspherical β-NAT particles involved in denitrification in the December 2011 Arctic stratosphere, Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-146, in review, 2016.

Wilks, D. S.: Statistical methods in the atmospheric sciences, Academic Press, International Geophysics Series Vol.100, 2nd edition, 2005.

Yang, P., Wei, H., Huang, H.-L. Baum, B. A., Hu, Y. X., Kattawar, G.W., Mishchenko, M. I., and Fu, Q.: Scattering and absorption property database for nonspherical ice particles in the near- through far-infrared spectral region, Appl. Opt. **44**, 5512-5523. 2005.

Zasetsky, A. Y., Gilbert, K., Galkina, I., McLeod, S., and Sloan, J. J.: Properties of polar stratospheric clouds obtained by combined ACE-FTS and ACE-Imager extinction measurements, Atmos. Chem. Phys. Discuss., 7, 13271-13290, doi:10.5194/acpd-7-13271-2007, 2007.