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Interactive comment on "Spectroscopic evidence for β-NAT, STS, and ice in MIPAS infrared limb emission measurements of polar stratospheric clouds" *by* M. Höpfner et al.

Anonymous Referee #2

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Review of: Spectroscopic evidence for beta-NAT, STS, and ice in MIPAS infrared limb emission measurements of polar stratospheric clouds, M. HĺopfnerI, B. P. Luo2, P. Massoli3, F. Cairo3, R. Spang4, M. Snels3, G. Di Donfrancesco5, G. Stiller1, T. von Clarmann1, H. Fischer1, and U. Biermann6,*

This paper presents an interesting analysis of austral winter PSC measurements using lidar and limb infra-red emission measurements. The lidar data are used to select clear examples of the three types of PSC particles, NAT, STS, and ice, then Mie calculations are used to investigate the size distribution and composition of the PSC particles. For each case infra-red indices of refraction are used for all known phases of PSCs, alpha-, beta-NAT, STS, ice, NAD, and then size distribution parameters are adjusted until the modeled emission matches the infra-red interferometric measurements. The assumptions on the size distribution parameter space are quite restrictive, i.e. height independent median radius and distribution width, but reasonable matches to the spectroscopic radiances measured are obtained and thus compositions can be identified. Although the paper is acceptable it could be improved with some additional clarifications as outlined below. I also include some suggestions for improved wording in paragraphs I found confusing.

Clarifications, using page_number.line-number(s) for location:

1)More effort should be expended to establish that, for each of the three case studies of PSC type, it is reasonable to assume the same composition throughout the entire PSC column. This is most important for the cases of ice and NAT. For example, ECMWF or NCEP temperature profiles presented along with the lidar measurements, compared with equilibrium temperatures for the PSC phases, based on the gas phase mixing ratios measured by MIPAS-ENVISAT, will help to convince the reader of the uniformity of the PSCs for each case day. This may be less important for the optically thick ice cloud if MIPAS is obscured below a certain altitude.

2)How reasonable is the assumption of constant median radius and distribution width for the whole profile? Are there examples from the literature with little variation? Will the model calculations converge without imposing these restrictions? Does this limit the use of this technique to infer PSC phase?

3)In the discussion of Figure7, perhaps it is worth mentioning again that sigma and rm are assumed constant with altitude. This will help the reader to understand that the aerosol volume is only controlled by N(h), thus the same curve can represent both number and volume. I found this confusing initially.

4)What exactly does N(h) mean? For a standard definition of size distribution N repre-

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sents the total number concentration for all particles > some lower size, Rlower, but in the stratosphere at these altitudes this number, represented by condensation nuclei (r > 0.01 um) measurements is approximately 10 cm-3. Clearly here a different definition is being used which provides a range from < 0.01 to > 60 cm-3. Thus the authors have imposed some lower radius limit on the first moment of the size distribution integral to obtain N(r>Rlower) where Rlower changes with PSC phase.

5)10694.8: I would recommend that the phrase, "with the assumptions of a height-constant median radius between 0.2 and 9 um, and height-constant distribution width of 1.35." be added at this point. A nearly similar statement in the middle of the following paragraph gets lost. But in either case some additional explanation, as mentioned above would be appreciated to say either why it is necessary or why it is justified to do this.

6)10696.11- : Volume densities are also shown Ě This discussion of the derivation of number/volume needs clarification. Do the volumes shown arise from fitting the measured spectra to infer N(h), rm, and sigma, and then calculating volume from the lognormal size distribution parameters inferred, or does the volume arise from an altitude profile of aerosol absorption (emission) which is directly proportional to volume in the infra-red? At first it sounds like the former and then the latter. Please rework this paragraph to make it clear. If both are used do they give the same answer? What this consistency check completed?

7)10696.16- : Ě sigma to a constant value of 1.35. Why so exact for this assumption? Is there a basis for this value? It seems a bit narrow particularly for STS clouds.

8)10696.18- : Please use the correct gas phase mixing ratios for each case the first time. The readers don't need to be confused with an incorrect calculation. If you need to later explain a disagreement at low altitude for NAT then you could introduce alternate gas phase mixing ratios, but only if they lead to a useful conclusion.

9)10700.24- : This paragraph is forced. Although the authors seem convinced that this

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was really an ice observation, the data presented and the arguments are not convincing. The authors argue that the temperatures and MIPAS observations surrounding this period all suggest ice, while the lidar saw NAT throughout its profile. So why didn't the lidar see ice? Also why are the authors so convinced ice was present? Region 4 includes NAT, STS, and ice, thus there is no compelling argument from what is presented to suggest ice was present instead of large NAT particles. I suggest reducing this discussion and include mention of the fact that the MIPAS measurements are equivocal while the lidar measurements clearly indicate NAT.

10)10701.6- : There is again the indication that even though regions R2 and R4 are ambiguous, the authors use a more strict interpretation, i.e. that R2 indicates STS. According to Figure 9 R2 can be either STS or NAT, and R4 STS, NAT, or ice.

Minor comments/English suggestions:

a) 10687.7-9: Which reference describes remote sensing measurements of total reactive nitrogen or gaseous HNO3. To my knowledge Fahey et al., and Arnold et al., discuss in situ measurements.

b) 10678.9-11: Same question for laboratory measurements of STS. Carslaw et al., and Tabazadeh et al., are modeling studies, which were initially compared with in situ aircraft measurements.

c) 10688.26-29: Suggest the following wording: MIPAS/Lidar coincidences in which the Lidar identified PSCs of one type over its entire altitude range were chosen to test the identification of PSC particle composition using collocated MIPAS observations. Detailed spectroscopic radiative transfer calculations, including new refractive index data for NAT, were used for comparison with the MIPAS observations.

d) 10689.12: Do you mean "tangent altitude separations of 3 km?

e) 10690.7: on 19 September

f) 10693.15, Eq(1): What does rs(h) in the denominator stand for?

g) 10695.2: Ě in the MIPAS channels used Ě

h) 10696.8-10, Suggest rewrite as: Figure 7 shows MIPAS retrievals of PSC number density profiles for those median radii and refractive indices which provide the best fits to the measured spectra.

i) 10696.14-: However, as has been shown by, e.g., Echle et al. (1998 1998), it is not possible to obtain independent information on

j) 10697.10: Is there not a better reference on ECMWF temperatures than a personal communication?

k) 10697.16: Ěat the cloud top there is some information." What information is there?

l) 10699.22-: Awkward, suggest changing to: The detection limit for PSCs from MIPAS has been set to CI $<$ 4.5, (Spang and Remedios, 2003 2003) . Our simulations show this is equivalent with a detection limit of PSCs with volume densities of 0.2-0.4 um3cm-3. PSCs with volume densities less than 0.2 um3cm-3 are not detected while all PSCs with volume densities $>$ 0.4 um3 cm-3 are detected.

m) 10699.28: "For the comparison" confusing what comparison?

n) 10703.1: This sentence is confusing. How about: Radiative transfer modeling using indices for NAD, STS, or ice, do not match the spectroscopic measurements when the sharp feature at 820 cm-1 is observed.

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