Atmospheric Chemistry and Physics Discussions

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Interactive comment on "First Odin sub-mm retrievals in the tropical upper troposphere: ice cloud properties" by P. Eriksson et al.

P. Eriksson et al.

Received and published: 27 October 2006

The referee identifies the paper as important. The only criticism regards two points associated with the presentation: 1. Error sources shall be summarised more systematically. 2. Not only scattering, but also absorption, of the ice particles shall be considered in the text.

Point 1: The referee suggests a table summarising the errors. A clear summary of this kind is always a good idea and will be included in the final manuscript.

It can be mentioned that the error sources identified by the referee have all been considered, where details are given in the accompanying paper by Ekström et al. The found brightness temperature uncertainties have not been mapped quantitatively to IWP (ice water path) retrieval errors, as these errors are of limited importance com-

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pared to two other effects. The missing qualitatively error estimates will be included in final manuscript. The two dominating effects are the influence of limited knowledge on the particle size distribution and horizontal inhomogeneities of the ice field. Unfortunately we missed to include a discussion of the impact of inhomogeneities (see comment by Cory Davis). This oversight will also be resolved.

Point 2: First, it shall be clarified that the absorption of the particles is included in the calculations and any shortcoming is limited to the text. The exact phrasing will be revised, but the existing text is mainly correct.

The absorption is larger than scattering for particles up to about 50 μm (spherical particles assumed), as pointed out by the referee. However, the impact of a given extinction, on observed brightness temperature, is different between absorption and emission. Both extinction processes have also a corresponding source term. In the case of absorption, the source is emission, while in the other case it is scattering into the line-of-sight. The relative importance of absorption and scattering will then differ, depending on both local and non-local conditions. For the observation geometry considered in the paper, scattering will have a larger impact than (particle) absorption. This is the case as the brightness temperature of absorbed and emitted radiation is quite similar (difference < 25 K), while for scattering "lost" and "gained" brightness temperature differ more (in the order of 100 K). Average brightness temperature of radiation scattered into the line-of-sight should be in the order of 100 K (in rough terms: mean of 0 K coming from above, and 200 K coming from below), which can also be deduced from lowest values in Figure 2. Scattering (where gaseous absorption is low) is accordingly a factor 4(-20) more efficient than absorption, in terms on impact on spectra. Including this effect, the brake point between absorption and scattering is then found around 25-30 μm.

Figure 1 can be used to exemplify this. It shall here be remembered that the ice particles are "seen" with a blackbody background with a brightness temperature of about 210 K. The discussion would be quite different with "cold space" as background. If

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the ice particles (in Figure 1) would only cause absorption, the observed brightness temperature should always be around the physical temperature of the atmosphere. A Rayleigh-Jean definition of the brightness temperature is here used. If a Planck definition would have been used, observed brightness temperature could in fact never be lower than the atmospheric temperature at the position of the ice particles. It should then be clear that measured brightness temperatures below 180 K can only be explained by scattering.

The discussion above was limited to the impact of single particles. For the overall importance of absorption and scattering, also the particle size distribution (PSD) must be considered. The Odin-SMR detection limit corresponds roughly to an ice water content (IWC) of 0.001 g/m^2. For this IWC, and if the PSD of McFarquhar and Heymsfield (1997) is assumed (as in the paper) and a temperature of 230 K is considered, a test calculation gave that the particle extinction is caused to 89 % of scattering. Absorption will though be important at lower IWC and colder temperatures as the PSD then will include less large particles.

To conclude, scattering dominates in general strongly the impact of particles on Odin-SMR spectra, but absorption can have a significant effect for the thinnest (with respect to the Odin-SMR sensitivity) clouds, especially if they are found close to the tropopause (and thus at cold temperatures).

Regarding p 8696, line 5: The sentence starting here is misleading, as pointed out by the referee. We appreciate that the referee has taken time to make calculation in order to give such detailed (and correct) numbers. Yes, the maximum sensitivity to 200 μm particles is a combination of Mie effects and the assumed gamma size distribution. The sentence will be changed to better reflect this fact.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 8681, 2006.