Atmos. Chem. Phys. Discuss., 6, S4470–S4474, 2006
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Atmospheric Chemistry and Physics Discussions

Interactive comment on "First Odin sub-mm retrievals in the tropical upper troposphere: humidity and cloud ice signals" *by* M. Ekström et al.

M. Ekström et al.

Received and published: 9 November 2006

We appreciate the referee's comments and ideas to further clarify the methodology and error estimation. The technical/typographical points will be corrected in the revised version. For the more specific questions, some of the points have been grouped together in the answers.

Point 1:
Although the paper describes a method to detect clouds and correct the retrieved UTH with some empirical components, as pointed out by the referee, the underlying understanding of the cloud influence has been achieved through radiative transfer calculations involving cloud scattering. For example Rydberg (2004) has provided a lot of

insight in the influence of scattering on measured brightness temperatures. The sentence (p. 8652, l. 4) is not meant to imply that the detailed radiative transfer calculations are used in the paper, but rather that they have prepared the ground for the work in this paper.

Second, as pointed out by the referee the absorption of ice particles dominates over scattering for small particles (<50 μm radius). This has been addresses in the discussion around the accompanying paper by Eriksson et al. (see http://www.cosis.net/members/journals/df/article.php?a_id=4370).

Point 2:
There are some statements concerning the influence of clouds on the retrieval that the referee has questioned. The first (p. 8654, l. 6) is merely intended to place the retrieval method in relation to similar retrievals of other measurements. The cirrus clouds in the UT have less influence on sub-mm than on IR/vis measurements, without saying that sub-mm are insensitive to clouds. In the second sentence (p. 8655, l. 14) clouds should be included, as pointed out by the referee, since we do not yet assume clear-sky conditions. These two statements will be changed to clarify what we mean in the revised paper.

Point 3:
The sounding altitude of the measurement is estimated using the optical depth along the line of sight, τ. The optical depth corresponding to the sounding altitude does vary slightly with tangent altitude. For example, changing tangent altitude from 8 to 4 km will change τ at the sounding altitude by <2.5% for 501 GHz and $\approx$7.5% for 544 GHz. The optical depth also depends on humidity, and a parametrization of τ for different tangent altitudes and humidities could improve the estimation of the sounding altitude. However, to estimate the uncertainty in altitude it is important to note that τ increases rapidly with decreasing altitude in the UT for the two frequencies which makes the precise choice of τ less important. To summarize how the τ values were determined in a plot would be too complicated given that it is not a critical parameter. The estimated

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altitude uncertainty for the chosen τ is around 400 m.

Point 4:
The exact figures for the boundaries of the two frequency bands that are averaged for the clear-sky retrieval, will be included in the revised paper.

Point 5:
On p. 8657, l. 15 the T_B depression is said to be used for the cloud correction. This is incorrect and will be corrected. The quantity used for cloud correction is ΔT_B, i.e. the brightness temperature difference between the strong emission line and the averaged signal used for the clear-sky retrieval. The ΔT_B value is extracted from the measured spectrum and does not depend on simulations or assumptions of humidity. As such it also have rather high accuracy since we can neglect the calibration uncertainty and only have to deal with thermal noise.

Point 6:
There is a difference between the estimated errors for a calibration error and the ECMWF temperature uncertainty. The calibration affects the measured spectrum directly whereas a change in atmospheric temperature also affects the simulated brightness temperatures indirectly through e.g. changes in absolute amount of H_2O for a given RHi. This is the reason why the ECMWF error gives a smaller impact on the retrieval than a calibration/thermal noise error of the same magnitude. We will clarify this in the revised paper.

Point 7:
The estimated error for the assumption of constant RHi in the troposphere is given as an average deviation (p. 8662, l. 5). To be consistent this will instead be given as a standard deviation in the revised paper.

Point 8:
The referee raises two questions concerning the error estimation for clouds:

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First, the impact of thin cirrus clouds that can not be distinguished from high RHi signal. The value we use for detecting clouds is not dependent on the absolute brightness temperature. Instead we look at the contrast between two frequency bands in the spectra, ΔT_B, which is less influenced by temperature, humidity and calibration uncertainties (see Point 5). Undetected clouds will give a positive bias to the humidity error, whereas measurements falsely classified as cloud influenced will have a negative bias. Since the ΔT_B limits for cloud detection is based on statistics, both of these cases are expected to occur with roughly the same probability. Therefore we expect the systematic component of this error to be small. To quantify the random component in detail requires assumptions on cloud statistics that are beyond the scope of this paper.

Second, the effect of the cloud altitude is discussed by Eriksson et al. in the accompanying paper. In brief, a thin high cloud and a lower thicker cloud can have similar impact on the measured brightness temperature. From the data presented in this paper, these two cases can not be distinguished. Further, we assume that the altitude extent of detected clouds and the sounding region are overlapping in altitude. This was not clearly expressed in the paper, but will be in the revised version. The assumption is supported by the fact that clouds corresponding to an ice amount detectable by Odin-SMR seldom reach higher than around 15 km (this can be seen in Eriksson et al., Fig 7).

Point 9:
In the figure showing the histograms of the MOZAIC measurements and Odin-SMR 501 GHz measurements, the total number of measurement for each instrument will be included in the caption of the figure. As the humidity distributions shown in the figure are normalized, we expect the excess measurements of high RHi to be compensated by with a lower number of measurements of lower RHi. The difference between MOZAIC and Odin-SMR in the interval 60 and 80 %RHi can be considered as a smoothing of the distribution due to the large calibration uncertainty.

Point 10:
In the figures showing the horizontal distribution of the retrieved humidities all available

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values from each frequency bands are included. The pressure levels assigned to each humidity field are the average pressure levels for all the included values. The sounding altitude of UTH for Odin-SMR varies with humidity, and since we are dependent on averaging the data we also present the data on average pressure levels.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 8649, 2006.