

***Interactive comment on “Non-Gaussian Bayesian retrieval of tropical upper tropospheric cloud ice and water vapour from Odin-SMR measurements” by B. Rydberg et al.***

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**Reviewer 2**

1. Given that the procedure for generating ice particle size distributions from radar reflectivity in Rydberg et al. (2007) included variations in the mean particle size and width of the distribution, there ought to be a stronger justification for not using that procedure in the current algorithm. Was there a computational limitation? The current method underestimates the IWC retrieval error, as the authors acknowledge, but their simple means of adding in estimated errors from the previous 1D retrievals is not particularly satisfying.

C507

**Reply**

Odin-SMR measurements provides no mean in estimating particle size distribution parameters. In order to be able to retrieve ice water content, assumptions regarding the size distributions must be made. The method to create variations in size distribution parameters presented in Rydberg et al. (2007) was used in order to predict what an instrument dedicated to measure some size distribution parameters would be able to measure. In principle, and ideally, one could have applied the approach presented in Rydberg et al. (2007) in order to include variabilities in the size distribution. However, recently there have been articles reporting about problems in in-situ measurements of size distributions. Thus, the variabilities of size distribution parameters are highly uncertain, and it is therefore difficult to decide how much the parameters should vary. Another reason for applying a fixed size distribution parameterisation is that it will be simpler to compare achieved results with results from similar instruments. That is, it will be much simpler to compensate for assumed assumptions when comparing results.

**Reviewer 2**

2. The problem with using mass equivalent ice spheres for the scattering calculation is not only one of polarisation. At submillimetre-wave frequencies the scattering properties (e.g. extinction and asymmetry parameter) of mass equivalent ice sphere deviates substantially from more realistic, low density ice crystal habits. This issue should be explored and discussed more thoroughly.

**Reply**

We agree that this can be discussed more. Evans et al. (1998), "Modeling of Submillimeter Passive Remote Sensing of Cirrus Clouds", J. Appl. Met. (37), (this reference will be added) shows that radiative transfer in cirrus clouds at 500 GHz are to some extent sensitive to particle shapes (for example in Fig. 8). On the other hand, it is also shown that simulations with distributions of mass equivalent spheres gives results that fall in between the results of simulations with more complex and low density shapes.

C508

By considering that a cloud consists of a variety of particle shapes, we assume that mass equivalent spheres closely describes the averaged scattering properties of realistic clouds. This will be more discussed in Sect. 4.1.2. Clearly, particle shapes deviating from spheres can give rise to polarisation effects. Odin-SMR measures at  $\pm 45$  degree polarisation, which is almost the same as measuring the total intensity. This is an advantage for ice mass observations as compared to only measuring horizontal or vertical polarisation. For example, in Eriksson et al. (2007) it is shown that horizontally aligned spheroids tends to favour scattering of the vertical component of the radiation, as compared to spheres. On the other hand, these spheroids scatter less of the vertical component of the radiation than spheres. By considering the scattering of the total intensity, there is a very small difference between spheroids and spheres. From this, we draw the conclusion that w.r.t to the total intensity, polarisation effects induced by complex shaped particles tends to cancel out.

#### **Reviewer 2**

3. There should be a little more explanation of how the retrieval accuracy is determined (e.g. in Figs 7 and 9).

#### **Reply**

Accuracy is the degree of closeness of a measured or calculated quantity to its actual value, and that is exactly what the figures show. Since it seems not to be totally clear how the figures were produced we will include a short explanation of this, although in Sect. 5.2 "Retrieval setup and characterisation" the basics of the retrieval setup is already discussed.

#### **Reviewer 2**

4. In Section 6.2 there should be more emphasis on comparing the 3D a priori IWC retrievals with purely 1D retrievals, since that is the novel element of this new retrieval algorithm.

C509

#### **Reply**

In the earlier Odin-SMR retrieval algorithm, presented in Eriksson et al. (2007), 1-D retrievals were applied, and a compensation factor to compensate for beam-filling effect had to be introduced. The presented results are compared to these results, and it was found that such a compensation was necessary to get the results to agree. A more detailed comparison than this would require a substantial amount of work, and could be an article by itself.

#### **Reviewer 2**

5. I question whether the CloudSat-c IWC averaging method is appropriate because it uses the averaging kernel of the SMR retrieval algorithm, and is thus not independent of the current retrieval algorithm. Isn't the goal to compare the IWC averaged over the same physical volume, and not considerations of correlations between layers due to the retrieval algorithm? Some discussion of this issue would be appropriate.

#### **Reply**

We agree that CloudSat-c IWC is not independent of the Odin-SMR retrieval algorithm. But applying derived kernels, which is affected by correlations between layers, is normally the way to proceed when comparing results from sensors with different resolutions. So this is not anything that is unique with this paper. However, the kernels derived for Odin-SMR is mainly derived in order to get a rough estimate of the vertical resolution of Odin-SMR, and is an average over the complete training data ensemble. It is therefore not totally appropriate to use it the way we have applied in the comparison and this will be more discussed.

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