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Interactive comment

Interactive comment on "Improved rain-rate and drop-size retrievals from airborne and spaceborne Doppler radar" *by* Shannon L. Mason et al.

Anonymous Referee #1

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This is an interesting study which demonstrates the utility of measurements of Doppler velocities (in addition to those of reflectivity) for retrievals of rainfall parameters from nadir-pointing W-band radar. These additional measurements will enhance precipitation retrievals from perspective spaceborne EarthCARE cloud radar compared to CloudSat. Multiple scattering, which is not a significant limiting factor with airborne measurements considered in this study, however will complicate spaceborne retrievals. There are some important issues that the authors need to address before this manuscript is published as an article.

Major comments.

1. I wonder how the absorption by liquid water clouds is handled. Liquid phase clouds below the melting layer will contribute to the total PIA. Their contribution can be sub-

stantial especially for lighter rainfall. Neglecting cloud absorption will result in over-estimation of PIA due to rain. Cloud base heights can be significantly lower than the melting layer.

2. Assuming that Nw is constant with heihgt does not account for drop collision-coalesence, evaporation and break-up processes. It is a rather heavy assumption and it needs more justification.

Other comments

1. Do you account for changes in raindrop terminal velocities with altitude as air density changes?

2. From the text I understood that gaseous attenuation is calculated from model profiles of temperature and humidity. In stratiform rain, however, relative humidity is often 90-95% and if model profiles suggest lower humidity (e.g., the model does not forecast rain in a particular pixel) the water vapor absorption contribution in PIA can be underestimated.

3. The statement that the gradient method requires an assumption of constant rain rate with height is misleading. In fact it requires an assumption that non-attenuated reflectivity changes are small compared to changes due to attenuation. This method provides an average rain rate in the height interval which is used to calculate the gradient.

4. When using 9.6 GHz data, do you account for rain attenuation at this frequency? Estimates show that attenuation at X-band at 10 mm/h at nadir pointing and in a 4 km thick layer could be around 1.3 dB. In addition to that the melting layer attenuation will add a contribution, which cannot be neglected.

5. How well are radar beams at X and W bands matched? The DDV measurements are very sensitive to beam mismatches.

6. I believe the reference to Matrosov et al. (2008) in JAS in line 10 on page 7 for eq. (6) is wrong, it should be the reference to Matrosov (2008) IEEE TGARS, 1039-1047,

doi: 10.1109/TGRS.2008.915757 This equation provides two-way attenuation. Your assumption of Xm=1 km actually corresponds to the melting layer thickness of 0.5 km, which accidently is about right as melting layers often have thicknesses of around 0.5 km. Please correct the reference and the Xm definition.

7. Figure 3. It appears that PIA is saturated at values lower than 60 dB, but the text says it is 65 dB.

8. Did you estimate what is the uncertainty of using the Mie theory instead of calculations for oblate raindrops?

9. Figure 4 shows PIA-based retrievals also for the period when the W-band signal was completely extinguished (between 16:02 and 16:03 UTC), so PAI was not available. How it is possible?

Editorial comments

1. Since you use natural logarithms in (4), (5), (9) and Table 1, you should change "log" to "ln".

2. Page 8 line 24 and Table 2: 3 dBZ -> 3 dB (relative units).

3. Table 2. You do not measure Z as it is given in (7), but rather you measure attunuated Z.

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