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Interactive Comment

Interactive comment on "Cloud radar with hybrid mode towards estimation of shape and orientation of ice crystals" *by* A. Myagkov et al.

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The manuscript presents an interesting and important study of retrieval cloud particles' characteristics from differential reflectivity (ZDR) and the correlation coefficient (CC) measured with polarimetric radar operating at a frequency of 35 GHz. Two measured radar variables allow retrieving the dielectric axis ratio and degree of orientation of cloud ice particles. The paper is a substantial contribution to radar remote sensing methods. The approach can be used for polarimetric scanning radars at other frequency bands such as X, C, and S.

I have two concerns about the authors' approach. The first is with the assumption about horizontal homogeneity in clouds. The authors assume horizontal homogeneity in clouds and measure ZDR and CC as functions of the antenna elevation angle. The analyzed cloud in Fig. 14 can be considered homogeneous to some extent, but other examples (Figs. 7, 8, and 17) are not stratiform clouds most likely (the initial "instant" radar cross sections are not shown). I think that homogeneous clouds are rear occasions. Secondly, bulk ice densities of the ice cloud particles remain unknown that make it difficult to estimate their physical axis ratios from the dielectric axis ratios. One more unknown comes from a possible mixture of plate-like and columnar crystals. It is of interest to estimate the retrieval uncertainties caused by these unknowns. It would be very informative if the authors plot the vertical temperature profiles in Figs. 14 and 17 to compare the retrieved particle shapes with the Magono's diagram.

Some technical issues. - Probability of orientation angle θ was described by a function that is valid for phase difference of correlated signals (eq. 66). This bell-shaped function can be used for the distribution because the true function is unknown, but functions such as Gaussian or Fisher are typically used for that and would be preferable. Instead of using the degree of orientation it would be preferable to see the standard deviations in orientations expressed in degrees as it has been done by many authors. - Averaging in orientation angle θ should be done over the solid angle. Thus, additional multiplier $\sin\theta$ and normalization factors should show up in (67)-(68). - Page 9113, lines 15-16. The authors state that "negative values of $\Delta\varphi$tp indicate that the horizontal transmission line is shorter than the vertical one". Values of $\Delta\varphi$tp will also be negative if a wavelength-long waveguide would be added to the current horizontal transmission line because of 2π phase periodicity. So the horizontal transmission line can be longer than the vertical one. - Nh and Nv are called the mean noise levels (page 9115, line 17). The mean noise level is typically determined for the whole spectrum. So Nh and Nv in the manuscript are noise levels in a spectral line. - Equation (8) causes an illusion that Ka is a function of frequency. Bhh(ω) and Bvv(ω) are estimates and experience variations. To obtain confident Ka, the authors average the estimates, most likely, is this correct? - The standard deviations in Hor and Ver noise are 0.01 and 0.011 (page 9123, line 1). What are the units of these values? - It remained unclear how the standard deviations

(SD) of the polarizability ratio and degree of orientation were calculated/estimated. The SDs are determined by the uncertainties in ZDR and CC measurements. It seems to me that the SD have been obtained from the scatter of measured values. This scatter can be caused by natural variability in particles' characteristics. So an analysis of SD caused by the uncertainties in measured ZDR and CC values would be informative for the separation of measurement and natural variabilities.

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