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Comment

# ***Interactive comment on “Remote sensing of ice crystal asymmetry parameter using multi-directional polarization measurements – Part 1: Methodology and evaluation with simulated measurements” by B. van Diedenhoven et al.***

**B. van Diedenhoven et al.**

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We would like to thank the reviewer for her very helpful and constructive comments. Below the comments are repeated before the responses. The exact changes to the final version will be listed in a separate online comment once the final version is submitted.

COMMENT 1: (Abstract, Conclusions.) Ice particles are not always randomly oriented

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in atmospheric clouds. The random orientation is crucial for your modeling. Please, underscore ‘the random orientation’ in Abstract and Conclusions.

REPLY 1: The assumption of “random orientation” will be explicitly mentioned in abstract and conclusions. It is already mentioned in the method section (page 4328, line 15 and 4329, line 8). Furthermore, we’ve added an additional reference to Breon and Dubrelle 2004 (Journal of the Atmospheric Sciences 61 (23), 2888–2898) who demonstrate that conditions that lead to crystal orientation are generally rare.

COMMENT 2: (Page 4328 lines 21 – 23; page 4329, lines 2 - 10.) It is mentioned that “a database of optical properties for hexagonal plates and columns is calculated using the Geometric Optics (GO) code developed by Macke et al. (1996)”. (Hereinafter, the quotation marks are used for the text from the discussion paper.) At the same time, a number of data were computed for size and/or aspect ratio values that are largely outside the limits where the geometric optics approximation is valid. It was proven by Mishchenko and Macke [2] on the base of an exact electromagnetic scattering technique that well-defined halos should be observable for ice crystal size parameters of the order of 100 and larger (or equivalent radii exceeding 10  $\mu\text{m}$  at visible wavelengths). You can use that criterion in your future investigations. The limit is somewhat lower when the GOM2 method is used (see [3] and references therein). Of course, the use of a gamma size distribution diminishes errors of modeling. Nevertheless, the question remains open. That is why it is written above that further investigations are needed.

REPLY 2: We agree that the geometric optics assumption does not apply to part of our LUT. However, the optical properties of complex habits and mixtures used for the simulated (validation) measurements are obtained using a combination of IGOM for large particles and discrete dipole approximation (DDA) for the smaller particles that fall outside the IGOM limit. By validating our approach on these simulated measurements we thus show that using the LUT calculated with GO yields results within our aimed accuracy (0.04). It is possible that if we improve the optical properties of the particles with size parameters below 100 in our LUT by using, for instance, DDA, the uncertainty

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of our approach would be reduced. This is indeed a subject of future work. We will discuss the above in the revised paper.

COMMENT 3: (Page 4329, lines 21 - 23.) I agree that that “the asymmetry parameter is not affected substantially by the size in the geometric optics regime”. But, ice cloud particles do not always obey the GO criterion. Thus, the sensitivity to the parameters of the size distribution should be addressed in your future work, especially since the degree of linear polarization is a constituent component of your approach.

REPLY 3: Please see the reply to the previous comment.

COMMENT 4: (Page 4330 and Fig.2.) Figure 2 shows degree of linear polarization as a function of scattering angle for hexagonal columns. For an experienced reader, it is clear why there were selected the measurements that contain scattering angles in the range 100-165 (see page 4332, lines 11 - 12). At the same time, Fig. 2 is not all-sufficient. The authors should add a figure with some examples of linear polarization as a function of scattering angle for bullet rosettes, aggregates, droxtals, and hollow particles. Otherwise, readers must search the mentioned plots in the literature in order to accept the selected range of scattering angles.

REPLY 4: A figure showing DoLP of droxtals, aggregates of columns, aggregates of plates, hollow columns and solid and hollow bullet rosettes will be added to the revised version of the paper as suggested.

COMMENT 5: (Page 4338, lines 24 - 25.) It is written: “Surprisingly, the results are 25 little affected by angular sampling, even when only 2 samples (at 100 and 160) are available”. There is nothing surprising. That property as as well the features of Fig.10 can be expected from plots of Fig.2.

REPLY 5: If not surprising, it is certainly interesting, as one of the other reviewers seems to agree on. We have replaced “Surprisingly” with “Interestingly”.

COMMENT 6: (Page 4340, lines 4 - 5.) The claim that the proposed approach “can

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be readily applied to RSP measurements and other current and past instruments” is greatly exaggerated. As it is underscored above, the modeling was performed for a number of cases that are largely outside the limits where the geometric optics approximation is valid; and ice cloud particles do not always obey the GO criterion.

REPLY 6: We agree that future studies using simulated measurements will be needed, and we will explicitly mention this in the revised paper. However, as with all remote sensing techniques (maybe especially those developed for ice clouds), part of the validation effort of such a method is applying it to real measurements to investigate where the room for improvement lies. The second part of this paper will be a first attempt of an application to real measurements. We have removed the word “readily” from the sentences in abstract and conclusions.

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Interactive comment on Atmos. Meas. Tech. Discuss., 5, 4321, 2012.

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