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Atmospheric Measurement Techniques Discussions

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.

V. Shcherbakov (Referee)

valery.shcherbakov@moniut.univ-bpclermont.fr

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General comments:

The asymmetry parameter is known to be one of the key parameters of the radiative transfer theory. Thus, it is of utmost importance for a cloud-feedbacks component of Earth's climate modeling.

The idea do not retrieve a number of possible parameters, but only one that is of utmost

importance, is ingenious and well grounded. The primary attention can be paid to the retrieval accuracy just of that parameter.

The second basic idea of the work under reviewing is the assumption that individual hexagonal ice columns and plates can serve as proxies for more complex shapes and aggregates. That idea seems to be very promising on condition that ice particles are randomly oriented. Indeed, it is reasonable to expect that the idea will work since surface roughness and internal inclusions of ice particles are known to hamper the formation of halos leading to phase functions, which are featureless (see, e.g., [1] and references therein).

To find good proxies is not an easy task. The inferred parameter must correlate (not necessary linearly) with the measured characteristics, whereas a number of other parameters are allowed to be free. It follows from the results of the work that the task was successfully fulfilled.

At the same time, it should be underscored that the work under reviewing is the first step in the promising direction; further investigations are needed (see, Specific comments below).

I recommend that the paper be published in ACP after minor revisions.

Specific comments:

1) Abstract, Conclusions.

Ice particles are not always randomly oriented in atmospheric clouds. The random orientation is crucial for your modeling. Please, underscore 'the random orientation' in Abstract and Conclusions.

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 μm 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.

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.

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.

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.

6) Page 4340, lines 4 - 5.

The claim that the proposed approach "can 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.

References.

1. Baran A. J., "From the single-scattering properties of ice crystals to climate prediction: A way forward" Atmospheric Research 112, 45–69, 2012.

2. Mishchenko, MI, Macke A. How big should hexagonal ice crystals be to produce halos? Appl Opt 38, 1626–1629, 1999.

3. Yang P, Liou K. N. Light scattering and absorption by nonspherical ice crystals. In: Kokhanovsky A. ed. Light Scattering Reviews: Single and Multiple Light Scattering, Springer-Praxis, 31–71; 2006.

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