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Interactive comment on "Ice particle habit and surface roughness derived from PARASOL polarization measurements" *by* B. Cole et al.

Anonymous Referee #2

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The paper describes the retrieval of ice particle habit and surface roughness from a large dataset of PARASOL satellite polarized reflectances containing between 50000 and 70000 pixel for each of the 4 days that were analysed. To my knowledge this is the first attempt to globally retrieve habit and roughness and hence this study is an important contribution for a better understanding of ice cloud microphysics. An interesting result is that the roughness varies considerably with latitude, which might be explained by different microphysical processes. In the tropics ice crystals are often generated by riming processes in thunderstorm anvils, whereas in midlatitude or polar region synoptic processes are predominant. The most often retrieved habit is the "compact aggregate of solid columns".

The paper is well organized and well written. My main concerns and questions are

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related to approximations made in the RT calculations (see below). When the authors have shown, that their RT approach is sufficiently accurate, I recommend to publish the paper in ACP.

Comments:

Sec 2.1: The radiative transfer code is validated against tables for Rayleigh scattering and for this cases very accurate. However, it is not clear how accurate the model is for ice cloud scattering, since the scattering phase function and other elements of the phase matrix have a strong forward scattering peak. It is mentioned in Sec. 2.3 that the delta-fit truncation method by Hu et al. (2000) is employed to truncate the phase function. How many Legendre-terms are taken into account, i.e. how accurate is the truncated phase function and how many streams are used in the RT calculation? Is the method employed for all phase matrix elements, how exactly does it work for the phase matrix and vector calculations? Hu et al. have described and validated the method only for scalar calculations. It would be helpful to validate the RT calculations against model calculations that allow to include ice phase matrices without approximations. Benchmark results for a highly peaked phase function are presented in Kokhanovsky et al., 2010, where 7 vector RT models are compared. Some of the models presented here are freely available and could be used for validation.

l. 143/144: In order to demonstrate the sensitivity on particle habit and roughness, it would be good to show a figure including the polarized radiance for all habits in the scattering angle range from 60 to 180 degrees.

l.180: Why is the averaging over the instrument response function to obtain bulk scattering properties done? It the RT calculation then done monochromatically? How good is this approximation?

l.188: It is claimed that the retrieval would be "fairly insensitive" to particle size. I am not sure if this assumption is valid. P12/P11, corresponding the polarized reflectance after single scattering, is quite sensitive to particle size for some habits, I would say

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that the sensitivity on particle size is as pronounced as on particle habit. It would be useful here to show a figure including RT simulations of polarized reflectances in the scattering angle range from 60 to 180 for various particle sizes.

Eq. 3: I assume that this shows the averaging over one element of the phase matrix, not the phase matrix itself.

Fig. 7-12: Do you have any idea about where the peak at roughness 0.5 comes from? This looks rather artificial.

Fig. 13: Why are there no calculation results at about 180° scattering angle?

l. 378ff: In my opinion the dependence on particle size can not be neglected, especially for the retrieval of roughness, since there is a strong dependence as shown in Fig. 11 and 12. The suggestion to use IR wavelength to obtain information on particle size and then perform the habit/roughness retrieval is very good and it should be recommended for further studies rather than concluding that particle size may be neglected.

Reference:

A. A. Kokhanovsky, V. P. Budak, C. Cornet, M. Duan, C. Emde, I. L. Katsev, D. A. Klyukov, S. V. Korkin, L. C-Labonnote, B. Mayer, Q. Min, T. Nakajima, Y. Ota, A. S. Prikhach, V. V. Rozanov, T. Yokota, and E. P. Zege. Benchmark results in vector atmospheric radiative transfer. J. Quant. Spectrosc. Radiat. Transfer, 111(12-13):1931 - 1946, 2010.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 29483, 2013.