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

B. Cole et al.

bryan.baum@ssec.wisc.edu

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Responses to Referee Comments RC C9120 by Anonymous Referee #2, 15 Nov 2013

The authors thank the reviewer for the useful comments and suggestions. Following are responses to the points raised in the review.

The adding-doubling code used in this study is based on the code described in de Haan et al. (1987), which has seen wide use and acceptance in the radiative transfer community. Many previous studies of ice clouds with highly peaked phase matrices have used this code or a similar one, including Chepfer et al. (1998), C.-Labonnote et al. (2001), and van Diedenhoven et al. (2012). The accuracy of this code for ice cloud scattering has never been in question to our knowledge, and as noted in the

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current study this code produces results agreeing with standard tables for Rayleigh scattering to six decimal places. In the study by Kokhanovsky, a modified adding-doubling technique is examined and results are found to agree with other methods, meaning it is unlikely that the adding-doubling code in this study will have significant errors for highly peaked phase functions either. Kokhanovsky's important work on this subject has been included as a reference for interested readers in section 2.1. To the best of our knowledge, the truncation of the scattering forward peak is the most feasible approach to deal with a scattering phase function that has a strong forward peak. When we use the Hu et al method, we first obtain the normalized phase matrix elements in the form of Pij/P11 where ij=12, 13, 14, 21, 22, 23... Then, we use Hu's method to truncate the phase function P11. Let the truncated phase function be P'11. Then, the truncated phase matrix elements are given in the form of P'ij=P'11*(Pij/P11). We carried out various sensitivity studies regarding the convergence of the simulated results with respect to the number of the terms in the truncation and found 36 terms to be sufficient for convergence.

143/144: The requested figure can be found in Cole et al. (2013), Figure 6. The polarized reflectance for all habits used in the retrieval database in the current study is shown there.

180: The averaging over the instrument response is done so that the simulation can be run for one wavelength, instead of preparing scattering properties for each wavelength in the instrument response and running many simulations. It is easier to get average scattering properties than it is to run the radiative transfer code for each individual wavelength and subsequently weighting the results. This should not introduce any appreciable errors.

188: While it is true that there is a difference in polarized reflectance as size changes for some habits, it is still the case that the ice habit and roughness will be the dominant influence on the polarized reflectance. Fig. 5 from Cole et al. (2013) presents polarized reflectances calculated using a mixture of different habits for four different effective

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diameters, showing relatively little change. It is also possible that the change in size has nothing to do with the change in polarized reflectance, but instead the change in aspect ratio of the ice particles as size changes (for the ice particles considered in the present study) is the cause of the difference in polarized reflectance (van Diedenhoven et al. 2012). We also believe that the comment is not valid that P12/P11 governs the polarized reflectances: it is P12. At this non-absorbing wavelength the particle size only influences the diffraction pattern, which is limited to forward scattering (i.e. between 0 and 20-30 degrees in scattering angle). These forward scattering angles are not viewed by POLDER/PARASOL.

Eq 3: Actually, Eq. (3) is applicable to the entire phase matrix.

Fig. 7-12: The peak at roughness 0.5 means that the polarization properties of the ice cloud pixels in the analysis match with simulated clouds having a roughness parameter of 0.5. This might mean that the ice in these cloudy scenes actually is quite rough, or the polarized reflectance could have a value matching with roughness 0.5 for some other, unknown reason. Cole et al. (2013) did find that a roughness value of 0.5 best matched with observations (also called “severe” surface roughness), so this value is likely not artificial, but it is unclear why this value is preferred in the retrieval.

Fig. 13: A random subset of the retrieved pixels for 1 August 2007 data were taken for plotting purposes so that the whole plot wouldn’t be turned solid black, if all the data is plotted the backscattering direction is filled in.

378: A recommendation to use this approach for future studies was added to the summary.

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