**Atmospheric
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Discussions

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

B. Cole et al.

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The authors wish to thank Dr. Bastiaan van Diedenhoven for his detailed, well thought out review of our paper. The following will address the points raised in his review.

Major comment 1:

The basis of the retrieval method in our study is van Diedenhoven et al. (2012, 2013), and that basis has now been more explicitly mentioned at key points in the paper. The approach in the current study is useful because of the wide use of the scattering properties library of Yang et al. (2013). Users of these scattering properties will likely benefit from the knowledge of which of these habits is most frequently retrieved in global satellite observations.

Major comment 2:

There will be some variation in polarized reflectance due to the aspect ratio changing as the size changes, but the advantage of including these results is that it allows users of this scattering properties database to see the behavior of the polarized reflectance for different ice effective diameters found in the database. Explanation of the influence that aspect ratio has on the polarized reflectance has been made more clear so readers know how to interpret the results for different sizes.

Major comment 3:

The error introduced by assuming the POLDER ice model for the optical thickness retrieval is circumvented in the revised paper by limiting the analysis to pixels with a retrieved optical thickness of 5 or greater so that polarized reflectance is saturated. The retrieval results are actually changed very little with this restriction. Upon looking at the optical thickness retrieved for the POLDER pixels, the majority are optical thickness >5. This could possibly come from the previous restrictions placed on the data (e.g. must be over ocean, 100% cloud cover with at least 7 viewing angles covering at least 50 degrees, etc.). Another possibility is that for a given 3x3 POLDER superpixel to be classified as 100% cloudy, the ice cloud must be optically thicker. In other words, thin cirrus might not completely cover a 3x3 superpixel or might not be recognized by the POLDER algorithm somehow. Additionally, C.-Labonnote et al. (2001) reported that the current POLDER algorithm only concerns ice clouds with optical thickness > 1, so very thin clouds would be excluded anyway. In the same paper, C.-Labonnote also found that clouds with optical thickness > 1 have the same dominating shape or at least the same optical properties in their uppermost level. In light of that, perhaps it's not surprising the results were unchanged when the analysis was limited to optical thickness > 5.

Major comment 4:

Because the retrieval and analysis was changed to account only for clouds with optical

thickness of 5 or greater, we believe this comment no longer applies.

Major comment 5a:

The issue here is trying to fit the simulations to the measured polarized reflectances in the 60-90 degree scattering angle range where there is more variability (greater spread). As noted in comment 5b, this result is similar to previous results where the large variability at these small scattering angles was also not captured. A couple things could be going on here. It is possible that the lookup table used in this study is not comprehensive enough to capture all of the ice microphysics. It is also evident that some (but not all) of these very large polarization values at small scattering angles occur when the viewing zenith angle is very large (greater than 65 degrees). Not all geometries for a given pixel will have viewing zenith angles that large, so usually a pixel will have polarized reflectance values following the general trend and then an anomalously large value at small scattering angles. For some reason this is difficult to reproduce in simulations, and it's unclear if this is a limitation of the microphysical model, a limitation of the POLDER sensor or algorithm, or something else entirely. Some of the RRMSE values can be increased slightly if a large measured polarized reflectance is included with a pixel's retrieval, but of the up to 16 polarized reflectance values associated with a given pixel's retrieval, normally just one (rarely two) has a large value. The RRMSE doesn't get so large as to be meaningless.

Major comment 5b:

As noted in our response to comment 3, it turns out that a majority of the POLDER pixels have optical thickness values greater than 5, which is possibly due to the selection criteria used. Anyway because we now deal only with cloud optical thickness > 5 this problem no longer apply in the present study.

Specific comments:

1. Introduction:

All requested changes have been made, including putting a more thorough explanation of the basis for this paper being van Diedenhoven et al. (2012, 2013).

2.2 PARASOL satellite data:

The selection of data over the ocean has been made more explicit.

After checking the scattering angle range of the observations, almost all have at least some coverage in the 120-150 degree scattering angle range. Even without full coverage in this range, Cole et al. (2013) showed in Fig. 6 that for severely rough ice, a distinction among the habits used in that study (the same ones at the current study) is still possible. The Cole et al. study looks at ten distinct geometries, but if a lookup table composed of a wide range of aspect ratios is used as in van Diedenhoven et al. (2012), then a selection criterion for the 120-150 degree scattering angle range might be necessary. In any case, it should not make a difference in the current study since almost all the pixels meet this condition anyway.

Reference added to C.-Labonnote et al. (2001).

Sentence has been changed as suggested.

2.3 Ice Properties:

Since the scattering angle range for the POLDER pixels used contains 120-150 degrees, adding a figure like Fig. 3 from van Diedenhoven et al. (2012) seems extraneous. Baum et al. (2010) presented results for the impact of roughness on the degree of linear polarization for many of the habits used in this study as well.

References to the Baum et al. papers have been added.

2.4 Retrieval:

Sentence changed to suggested text.

The difference between this study and van Diedenhoven et al. (2012) has been made

more explicit.

The selection of viewing geometries is actually made already in the POLDER Level-2 product. As described in the User's Manual for Level-2 POLDER products the view zenith angle, sun zenith angle, and relative azimuth angle for the central pixel are used to describe the super-pixel (even though individual values are being used for the retrieval itself). This has been made more clear in the paper.

The sentence referring to Cole et al. (2013) has been removed.

3. Results:

The limitation of data to ocean scenes has now been made clear.

The suggestion sentence has been removed.

Figures 6 and 12 have been removed per the suggestion and instead their relevant information mentioned in the results section.

4. Summary

Mention of the basis of this work has been included in the summary now. The following has been added : "The retrieval method employed here is similar to van Diedenhoven et al. (2012), with the major difference being the varying aspect ratios used in the retrieval lookup table in van Diedenhoven et al. (2012). In the current study ten pre-defined shapes with varying roughness are employed."

Mention of restriction of data to ocean added.

Reference to van Diedenhoven et al. (2012) and relevant information now included.

Reference changed to van Diedenhoven et al. (2013) and requested change made to wording.