Atmos. Meas. Tech. Discuss., 5, C1384–C1387, 2012
www.atmos-meas-tech-discuss.net/5/C1384/2012/

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.

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Received and published: 19 June 2012

1 General comments and recommendation

This manuscript is an algorithm and sensitivity study for the retrieval of ice crystal asymmetry parameter (and optical thickness, for optically-thin clouds) using multidirectional polarized reflectance measurements such as made by POLDER, RSP or

similar instruments. The authors note that a forthcoming second paper will apply the algorithm presented here to real measurements.

The paper is clear and well laid-out, contains a useful uncertainty analysis, and I feel it achieves what it sets out to do. The asymmetry parameter is useful to know to e.g. parameterise the radiative properties of clouds, so the results will be of scientific utility. The study suggests that the goal of achieving retrieval of asymmetry parameter to within 5 % should be achievable with current and future sensors. I have no major problems with the work presented. For these reasons, I favour publication of the manuscript in AMT, following some small clarifications.

2 Specific comments

Page 4,325 and Fig 1: the authors provide a nice summary of previous measurements of asymmetry parameter. I note the range of values in the quoted literature is 0.65 to above 0.95. The corresponding limits of Fig 1 are narrower: the colour scale goes from 0.71 to 0.93, and these edge values are only found in quite extreme roughnesses/aspect ratios. Do the authors have some comment on their LUT being narrower in range than the literature–would extending the roughness or aspect ratio range help, or would that result in unphysical particles? Do you think these extreme values in the literature are a result of instrumental problems, unusual situations, or just different shapes (i.e. not plates/columns)? Is there some other factor which is limiting the range of asymmetry parameter going into your LUT? This would be nice to note in the paper.

Page 4,330, lines 7-8: in this notation the DOLP is just Equation 3 (R_p) divided by the

total reflectance I, correct? Or am I misunderstanding? I suggest stating this explicitly, for clarity.

Page 4,330, Section 3.4, and associated figures: you show quite nicely the uncertainties on your retrieval from simulated data and how these are affected by noise, sampling and so on. You are only using the polarised reflectance. Can you comment on whether or not considering the total reflectance as well would be likely to decrease these uncertainties significantly, or does it not add much extra information? I would imagine the biases might not change much but wonder whether the standard deviation envelopes would get a bit thinner. Alternatively, would much be gained from also considering polarised reflectance at a second channel in the retrieval? What I find particularly interesting from Fig 10 (b) is that it seems that using only 5 or so measurements gives similar uncertainties on asymmetry parameter to using 80 measurements (i.e. there must be some degeneracy in the information content), suggesting to me that to further shrink this envelope, a different type of information is needed: perhaps either total reflectance or a second wavelength. Or perhaps the remaining uncertainty is more linked to the ice crystal shape/size distribution assumptions. Some brief discussion would be welcome.

As a final suggestion: for completeness, I think there are a few more points which could be discussed briefly and perhaps quantified. These simulations were performed for ice clouds above a black surface. What happens if the surface is different, e.g. a land surface or an ice cloud above a water cloud? Can you say anything about vertical inhomogeneity of clouds; I guess the algorithm would retrieve some average asymmetry parameter, weighted towards the ice cloud properties near the top of the cloud? Perhaps these aspects will become more apparent in Part 2 where real measurements are used, but it would be nice to have an idea of what we might expect from the simulations.

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