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Title: Remote sensing of ice crystal asymmetry parameter using multi-directional polarization measurements - Part 2: Application to the Research Scanning Polarimeter

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General Comments:

This paper makes a unique contribution to our understanding of ice cloud remote sensing and optical properties. I am not aware of any other study where a potential method for retrieving the asymmetry parameter g from satellite is demonstrated (assuming the RSP can be adapted as a satellite instrument). Also unique is the retrieval of the median ice crystal aspect ratio and surface roughness (using surface distortion as a proxy?). Comparisons between retrieved and in situ measurements of g yield important insights, reinforcing earlier evidence that g can be parameterized in terms of the effective ice crystal aspect ratio. Whether the retrieval method retrieves the mean aspect ratio of ice crystals actually present is not clear, since a mix of habits or shapes is generally present, some planar and some columnar in structure. Is it possible that scattering contributions from both planar and columnar crystals conspire to produce a scattering signature corresponding to an aspect ratio near unity (as found in this study)? If so, would the scattering contributions combine in a linear fashion that would allow one to deduce the representative ice particle shape, whether it be individual or combined in aggregates?

The paper is well written and organized, and is worthy of publication in ACP. Some specific comments follow, which should be addressed in a revision of this paper.

Specific Comments:

1) Page 32065, line 6: Consider adding “and aspect ratio” after “radius”.

2) Page 32067, line 7: Normally g is described as a function of aspect ratio and surface roughness, although the exact physical nature of surface roughness may be difficult to characterize and model. My understanding is that surface distortion refers to the tilting of crystal facets, and that both surface distortion and surface roughness tend to produce a featureless phase function. In this work g is a function of aspect ratio and surface distortion. Is surface distortion used here as a proxy for surface roughness? Please discuss.

3) Page 32078, lines 1-7: Ice particle size distributions (PSD) tend to broaden (i.e. ice particle sizes increasing) with decreasing height. Ice crystal observational studies like Auer and Veal (1970, JAS) clearly show that aspect ratios depart further from unity (becoming smaller or larger than 1.0) with increasing size. Therefore, based on the postulates of this study, g should increase with decreasing height. But here the CIN measures a weak decrease in g with decreasing height. Could this be due to shattering? Larger ice particles are more prone to shattering, and shattering may result in irregular geometries with aspect ratios closer to unity, producing smaller g values at lower altitudes. These points need to be discussed.

4) Page 32079, line 15: There needs to be some basis for equating distorted with roughened ice particles, which should be established earlier in the text.

5) Page 32082, text above Section 3.4: Baily and Hallett (2009, JAS) show that plates having aspect ratios near unity (e.g. ~ 0.3) only occur at cirrus temperatures when the supersaturation with respect to ice is relatively low. Do these results (median aspect ratio of 0.33) imply low supersaturations?
    a. Whether the retrieval method retrieves the mean aspect ratio of ice crystals actually present is not clear, since a mix of habits or shapes is generally present, some planar and some columnar in structure. Is it possible that scattering contributions from both planar and columnar crystals conspire to produce a scattering signature corresponding to an aspect ratio near unity (as found in this study)? If so, would the scattering contributions combine in a linear fashion that would allow one to deduce the representative ice particle shape, whether it be individual or combined in aggregates?

6) Page 32088, line 3: The g parameterization in Mitchell et al. (1996) depends on what shapes are assumed. When polycrystals (i.e. Koch fractals) are assumed, g is independent of crystal size and at visible wavelengths is 0.74. Thus the range of g produced in the cited g parameterizations should be 0.74 to 0.83 (not 0.78 to 0.83 as stated). Moreover, it may be worth mentioning that the main problem facing the atmospheric science community is defensible constraints on the range of g (which would guide us in what g parameterization to use). This study is very helpful in this respect.

7) Figure 2: The magenta dots indicating ground sites are barely visible. Please enlarge them.