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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "Optical properties of pristine ice crystals in mid-latitude cirrus clouds: a case study during CIRCLE-2 experiment" *by* J.-F. Gayet et al.

Anonymous Referee #2

Received and published: 16 December 2010

General comments

The paper examines two cases of mid-latitude cirrus and describes in detail their in situ properties and attempts to relate these findings to the atmospheric state and dynamics. For both cases of cirrus using CPI imagery to classify the particles they conclude that the habit distributions are largely composed of hexagonal ice plates. In accord with other literature this paper concludes that the scattering properties of cirrus is best described using habit mixtures that in some way have been randomized. The paper presents further evidence for this in the form of Polar Nephelometer measurements combined with CPI images of the hexagonal plate; their analysis reveals that in one case the plates are so randomized (inclusions plus roughness) that their scattering phase functions are featureless whilst in the other case a distinct 22o halo is observed and then the authors describe the environmental conditions required for the formation of halos. The authors also estimate a g value for the randomized particles of 0.79, which is to expectation for randomized plates. The authors postulate that the large extinctions measured by CALIOP might well be explained by horizontally-orientated hexagonal plates such as the ones observed in the two cases that have been presented.

The paper is a good contribution to the literature as it combines measurements of phase functions and theoretical light scattering calculations, environmental conditions, and PSD measurements in order to understand the scattering properties of cirrus. The findings of this paper will also be of use to GCM modellers as the authors give some indication as to the most likely environmental situation in which to find pristine hexagonal ice crystals. The paper should be published with minor corrections which are detailed below. Some further analysis and additional citations would also be of benefit to this paper.

Minor comments

1.Abstract. The abstract should just summarise results that the authors have found not postulations concerning the possibility of horizontally-oriented plates being responsible for CALIOP high extinction measurements. They do not present any evidence for this as the high extinctions could also be caused by other oriented prismatic particles such as horizontally-oriented hexagonal columns.

2.Page 24764 line 22 citations should be Yang et al. 2001 to be consistent with other citations.

3.Page 24765 line 1. Other authors have used in situ single-scattering intensity measurements which sample the 22o halo region such as Field et al. (2003)[“A test of cirrus ice crystal scattering phase functions” GRL vol 30 art no 1752] and Baumgard-

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ner et al. 2005 [GRL vol 32 art no L01806]. These articles also deserve citation as they both add to the weight of evidence that cirrus is best described by randomized habit mixtures.

4.Page 24767. Concerning the discussion on ice crystal shattering. A further citation here should be the work of Field et al. (2003) who used the FSSP and showed that narrow PSDs are largely unaffected by shattering, this supports the view of the authors since their maximum dimensions were found to be < 250 μm. Field et al. (2003) [J. Atmos. Oceanic. Tech. 20, 249].

5.On page 24767 what is the definition of effective diameter that the authors use? Clarification required, is the De computed for d > 100 μm?

6.For both cases it would be useful to see a PDF of the contribution to the volume extinction coefficient made by each of the classified habits. This information can be obtained from the CPI. Although plates are common in both cases but do they also contribute most significantly to the measured volume extinction coefficient? In the calculation of the volume extinction coefficient do the authors assume the geometric optics limit, if so please state.

7.In the discussion of the phase functions for both cases (Figs 2 and 4) the meaning of the filled red circles is only stated in a later section, they are modelled phase functions; this should be stated before that section so the reader is clear as to what they actually are. Or remove the red circles and show later in the discussion section.

8.You should also show the RH for case A in Fig. 1.

9.For cases A and B can the authors identify which air mass the cirrus resided in as the rough crystals might have resided in a polluted air mass? This would be interesting to note and even do a back trajectory of the air mass to understand where it originated from? Further analysis of this type would add to the paper.

10.The PN is a very useful tool as you can try and estimate the degree of inhomogene-

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ity within the crystal and surface roughness. In the discussion section on page 24771 please state the fraction of air within the modelled crystals as well as the assumed degree of roughness or distortions? These need to be stated for both cases. Were the predicted g values within the PM uncertainty? You should put an error on the estimated PN g values and compare with theoretical values.

11.Just a note the Baran (2004) review has been updated and the Baran (2009)[JQSRT vol 110 pages 1239-1260] discusses the need for ensemble simulations and ice crystal complexity in more detail. Also, the need to relate ice crystal scattering properties to GCM prognostic variables is also discussed in the updated review, the authors are essentially starting this in the analysis presented.

Figures.

1.Fig 1. Include RH in this figure.

2.Fig 2. With the pie chart show also the contribution to the volume extinction coefficient made by each of the habits in the pie chart. State in the main text that the filled red circles are modelled points and these are discussed in section. . . etc.

3.Fig. 2. In fig. 2 (a) identify which lines correspond to which instrument. Also unit consistency in Fig 2a.

4.Fig. 4 same as 2 and 3 above.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 24763, 2010.