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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observing cirrus halos to constrain in-situ measurements of ice crystal size" *by* T. J. Garrett et al.

Anonymous Referee #1

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Review of 'Observing cirrus halos to constrain in-situ measurements of ice crystal size' by Garrett et al.

As the title suggests the authors attempt to use halo observations to place limits on ice particle sizes, thus providing an independent test of the in situ probe observations. I agree with the authors that utilizing such halo data has the potential to introduce extra information into the problem. However, I was left unconvinced by the arguments concerning the 'upper bound' constraint provided by the halo observation.

The constraint provided by the halo observations was not demonstrated, and therefore, the intention of the paper has not been fulfilled. Unfortunately, I feel that too much reinterpretation, reanalysis and reorganization of the paper will be required for it to be

acceptable in its current form and hence I have to reject the paper.

Major comments:

Halo observations

The assumption that only randomly oriented (in 3d) crystals form a halo is not correct (Tape (1984) discusses this in ch4). The high sun angles (small solar zenith angle) quoted in the paper means that horizontally oriented ice crystals that are randomly oriented in the horizontal plane can produce halos. This negates the aerodynamic argument suggesting that halos imply crystals smaller than 100 microns.

The presence of arcs (e.g. Fig 5) that would cut across the 22 and 46deg halos strongly imply the presence of horizontally oriented particles. Again, oriented particles allows the presence of larger than 100 micron crystals

The '46deg' halo in fig. 5 is not concentric with the inner halo and cannot be a true 46deg halo (at the top and bottom of the image it is considerably more than 46 deg from the sun). It is perhaps more likely an arc also formed by oriented crystals. The comparison of 46deg to 22deg halo intensity presented on p1308 is therefore not meaningful as the features being compared in the scattering function are not both present in the photograph (fig 5).

The other observations of a 46 deg halo, quoted in the paper, can infer the presence of plates (Pattloch and Trankle 1984). Mixtures of different crystal types in unknown quantities, unknown orientations and aspect ratios, are problematic for using halos as microphysical constraints.

The observations presented do not rule out the presence of oriented columns or other crystal types. Tape (1984) suggests that the range of particle sizes is 10microns (in agreement with the authors) to 1000 microns (10x the authors upper bound). Therefore, the authors have not convincingly demonstrated that the halo forming particles have to be smaller than 100 microns.

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Through reviewing this paper I have attempted to use a ray tracing program (Halosim3, freely available at http://www.atoptics.co.uk/halo/halfeat.htm) and have found that the number of degrees of freedom available is quite large. I feel that if any constraint can be obtained from halo observations, then all-sky camera views are required which can then be matched using ray tracing software to find a candidate population of particles. However, reading Tape's book suggests that surface and internal irregularities would still make this exercise a difficult one.

Other points

P1297, 12: Strapp et al. (2001, JTECH) suggest that the measurement of particles (strictly circular images) with diameter smaller than 100 microns will be problematic. The causes are related to detector response times and out of focus images.

P1300,5: To some extent the use of area equivalent radius is instrument resolution dependent.

P1305, 7: It would be good to see example images and explain how out of focus images were dealt with.

P1305, 9: How were the CAS particles sizes calibrated? Assuming scattering appropriate for water spheres will result in an underestimate of particle size because ice particles tend to scatter less light into the forward angles than a sphere with the same maximum dimension.

P1306, 19: What were the actual concentrations measured by the probes as opposed to normalised concentrations? Is the ice water content obtained consistent with that found by the Harvard instrument?

p1307, 10: What are the more general conclusions? Is it that habits differed?

P1309, 23: This sensitivity study is a bit extreme. I would suggest that various multiplication factors are considered (0.01,0.1,0.5 etc) rather than just removing the small particle mode completely. However, this point is moot since the arc in figure 5 does not

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appear to be a 46deg halo.

P1310, 20-25: See above (p1300,5; p1305,9) about sizing considerations. There could easily be a bias in sizing by a factor of 1.5 to 2 in the derivation of r_eq.

P1312, 24: Do not agree: oriented crystals can form halos - the presence of oriented crystals does not rule out the role of crystals larger than 100 microns in forming the halos.

p1312, 26-p1313, 5: Do not agree: not 46deg halo

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 1295, 2007.