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Atmospheric Measurement Techniques Discussions

Interactive comment on "Effects of ice particles shattering on optical cloud particle probes" *by* R. P. Lawson

Anonymous Referee #2

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Recommendation: Should be acceptable for publication after mandatory revision.

This paper analyzes data from the two-dimensional stereo probe collected during some specific case studies conducted during SPARTICUS, AIEE and in the Arctic to make the conclusion that a particle arrival time algorithm is more effective than the use of probe tips designed to reduce shattering. There are some fundamental flaws with the paper that makes it unacceptable in its current format. First, it needs to be better emphasized that the analysis presented in the paper applies primarily to the 2D-s, and that extensive analysis of data from other probes has not been conducted. Care should be taken to avoid generalizing a claim that is made for a specific cloud probe. Second, the paper makes the assumption that the "2d-s data are sufficiently reliable to be capable of revealing significant uncertainties in other cloud particle probe data."

Although the 2D-S has been shown to detect more particles in certain size ranges than other particle probes, it has not been convincingly demonstrated that the 2D-s probe is correct and that the other particle probes are incorrect. Third, and most importantly, there is really no way of knowing a priori how many small crystals that are present, and hence which calculation (i.e., modified or unmodified tips, arrival time algorithm applied or not) presents the "best" or "most accurate" measurement of small ice crystal concentrations. There needs to be some other independent measure of small ice crystal concentration (or bulk extinction, bulk scattering phase function, radiative flux) against which the various crystal concentrations can be compared. More specific recommendations for medication are included below. If the paper can be modified to address these comments, it should be published as the topic of shattering is very important for instrument-related issues in cloud physics.

1. The title is misleading and should be modified. As it stands now, the title makes it seem that the paper is examining the effect of particle shattering on all optical array probes. In reality, the paper is only examining particle shattering on one very specific probe, the two-d stereo probe. I would recommend a title such as "Effects of ice particle shattering on the two-dimensional stereo probe" to emphasize that a specific probe is being examined.

2. The author states that the 2DS had had its tips modified using the Korolev design technique. As I recall, there are several different designs for the 2DS tips, and that there has yet to be a demonstration of which is most effective at eliminating shattered particles. Thus, the author should clearly explain which redesigned tips are being used in this investigation.

3. The author also states that "the two size distributions that have been processed using the arrival time algorithm to remove shattered particles contain far fewer particles < 200 microns than either of the other size distributions." There is the implicit assumption that because these distributions contain fewer particles they are correct, whereas the other distributions are overestimates. What is to say that the algorithms

have removed real particles, and that therefore the other distributions are in fact more accurate? There seems to be no basis for this implicit assumption. I think there would be have to be some independent measure of bulk extinction or bulk scattering properties, or some more detailed radiative transfer calculations (comparing with surface radiative fluxes if the clouds were sufficiently homogeneous) for this conclusion to be justifiable. I see no way that the data presented show that the principal conclusion of the paper holds.

4. Figure 6 is somewhat convincing in making the case that shattering is occurring. However, some past studies have suggested that size distributions can be invariant (i.e., the shape of the size distribution does not change). The authors acknowledge this possibility in their analysis on the bottom of page 947. This is why an independent confirmation of their findings (e.g., against Raman lidar retrievals, bulk extinction or scattering measurements, radiative transfer calculations) would seem to be necessary more their conclusions to be robust. Without this, many of the statements on page 948 would seem to be overly speculative and yet to be verified. Note, the author essentially state this on page 950 when he states there is no way of knowing what the actual concentrations of small crystals are.

5. The fact that at least half the argument in the paper is based on a single flight at the end of SPARTICUS is suspect. This case is where the primary conclusions, with the AIIE results acting as more of a supplemental argument. Although it is entirely likely that the results from the SPARTICUS flight could represent cirrus clouds on the whole, it is a much stronger case if more flights were presented. This is acknowledged in the final paragraph, proving that the depth of this study leaves the reader wanting. It would be nice if more than a limited set of data were used in the investigations presented in this paper and that a more complete statistical analysis could be conducted to determine under which conditions the shattering is most prevalent (e.g., what crystal habits, crystal sizes, large crystal concentrations, etc.). In the absence of an independent measure of small crystal concentration or bulk extinction, this could strengthen

the conclusions of the paper.

6. I think the last section should be broken up into two sections, one each for discussion and conclusions. The way it reads now (at least to me) is pretty disjointed, as a lot of things are introduced that seem more deserving than just being dumped at the end of the paper. Bullet points at the end of the paper that outline the most important things to take away would be very helpful. Without such a list, it is more difficult to discern what is being pointed out. The introduction of new material in seemingly every paragraph makes it harder to recognize the main points.

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