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Atmospheric Measurement Techniques Discussions

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Interactive Comment

Interactive comment on "Aircraft testing of the new Blunt-body Aerosol Sampler (BASE)" *by* A. Moharreri et al.

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Reviewer Comment: "The above manuscript deals with the airborne characterization of an interstitial aerosol particle inlet. The authors are doing right going into that direction, because inside cloud measurements in the past were "always" influenced by cloud droplet or ice crystal break-up particles. And measurements of the interstitial aerosol inside clouds are needed for a better understanding of clouds. Hence the topic of this manuscript is of high relevance for atmospheric research. Therefore I recommend accepting the manuscript with one medium and some minor revisions.

General remarks: The development of BASE is a great step forward. However, my (only) medium concern is the underlying assumption of scatter particles staying in

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the inlet (or aircraft) boundary layer. In the past I might have agreed, but after I saw the videos by Alexei Korolov (ftp://depot.cmc.ec.gc.ca/upload/hsvideo/) I strongly doubt this assumption. Can you give a proof for this assumption? The assumption made in the manuscript is based on CFD modeling while the videos are based on reality. In any case you have to discuss this issue more in detail. Do you expect a difference between liquid droplets and ice crystals?"

Author Response: The reviewer's intuition is correct that shatter particles will not necessarily remain in the boundary layer of the inlet. Our findings from the first aircraft deployment of BASE (PLOWS) confirms that large droplets produced from the shatter of drizzle drops do make it to the sample flow and contaminate the aerosol measurements. Korolev's videos also show that large shatter ice particles, probably at least a few tens of microns, bounce significantly away from the inlet surface. In the revised design (BASE-II) we acknowledged this by redesigning the inlet as a cross-flow sub-sample tube, resulting in a cut-size of $\sim$ 2-3 microns. The design concept and simulations of BASE are indeed consistent with Korolev's observations. As shown in Fig. 7, for example, the simulations predict that shatter particles larger than $\sim$ 1 micron do exit the boundary layer of the blunt body housing and enter the interstitial inlet.

"Specific issues are:

- p. 2664, abstract: please write out also the acronyms for the two measurement campaigns."

Author Response: Text will be modified as advised.

-"p. 2664, l. 15: is "informed" the right verb here? I don't think so. Same p. 2674, l. 25."

Author Response: We will replace the old text: "the results from the improved flow model informed several design modifications of BASE" with "the results from the improved flow model were used to guide design modifications of BASE". A similar changed will be made in p.2674.

- “p. 2665, l. 14: please add the following two papers from Alexei Korolev as references after “secondary particles”: Korolev, A. V., Emery, E. E., Strapp, J. W., Cober S. G., Isaac, G. A., Wasey, M. and Marcotte, 2011, Small Ice Particles in Tropospheric Clouds: Fact or Artifact?, Bull. Amer. Meteor. Soc. 91, 967-973, doi: 10.1175/2010BAMS3141.1; Korolev, A. V., E. F. Emery, J. W. Strapp, S. G. Cober,.

A. Isaac, 2013: Quantification of the Effects of Shattering on Airborne Ice Particle Measurements. J. Atmos. Oceanic Technol., 30, 2527–2553. doi:http://dx.doi.org/10.1175/JTECH-D-13-00115.1”

Author Response: The recommended references will be added.

- “p. 2665, l. 28: is it really true that the scatter particles stay in the boundary layer of the inlet body? According to the videos or photos about cloud droplet scattering (e.g. on the DMT web page) you can see that the scatter particles well travel several centimeters crossing air stream lines. Hence I would say this requirement does not hold. Or is the velocity of your aircraft so low that it holds? I cannot imagine that, please discuss this point. And please provide the TAS of the C130 during your measurements somewhere in the text.”

Author Response: As also stated previously, only small shatter particles will stay close to the surface of the blunt body housing while large particles, similar to those observed in Korolev’s videos, will travel larger distances from the surface of the body. This will be better discussed in the revised text.

True airspeed for cloud events used in this study were mostly in the range of 125-150 m.s-1. This information is available in the figures showing flight data and will be added to the description of flight tests in the text.

- “p. 2666, l. 15: please add also the geographic region of the PLOWS campaign.”

Author Response: Most of the flights were out of Peoria, IL, USA and the range of coordinated covered in the campaign was approximately 32° N – 48° N and 81° W – 104° W. This information will be added to the text.

- "p. 2666, l. 23: how long is the flexible TSI tubing?"

Author Response: The flexible tubing was ∼ 7 ft. long.

- "p. 2667, l. 5: I tried to reach the web page for HIMIL (UCAR, 2005), but I was not successful. In the references you wrote it was last accessed 2005, i.e. nine years ago. Please provide a newer web reference or one that is working and if this is not possible provide a paper reference."

Author Response: Following references will be used in the revised manuscript:

Stith, J. L., et al. (2009), An overview of aircraft observations from the Pacific Dust Experiment campaign, J. Geophys. Res.,114, D05207, doi:10.1029/2008JD010924.

http://www.eol.ucar.edu/homes/dcrogers/Instruments/Inlets/ update Jan-2011.

- "p. 2667, l. 8: please be more specific concerning the mounting position of the inlets, how many meters behind the aircraft nose and how many meters apart?"

Author Response: The BASE was mounted ∼ 14m behind the aircraft nose and ∼ 1.5m off the centerline of the aircraft fuselage to the right side:

http://www.eol.ucar.edu/projects/plows/meetings/200909/pdf/Jensen_C130.pdf

We will add this information to the revised manuscript.

- "p. 2667, l. 19: what does "In designing BASE-I, the presence of only liquid droplets was considered" mean? What would be different, when considering ice crystals? And why restrict to liquid droplets only? Please explain this point in detail, i.e. in more than one sentence."

Author Response: Our initial goal for the deployment of BASE was to sample warm clouds to understand particle activation properties. That allowed us to consider clouds as being composed of liquid droplets. Modeling liquid droplet shatter is also relatively much simpler that modeling the breakup of ice and snow particles, which have no standard defined shape. Also, past observations suggested that shatter artifacts were more in warm liquid clouds than cold clouds (Craig et. al, 2013b, Weber et. al 1998), making it more critical to model liquid droplet interaction with the inlet surfaces. This will be better explained in the revised text.

- "p. 2668, l. 11: what are the cut sizes of the inlets? I would assume that the upper inlet cuts are at some micrometers and in this size range, the particle number concentration is so low that the different cuts do not make a big difference in CN. Or are there differences in the lower cuts?"

Author Response: Both inlets have cut-sizes larger than 1 micron (Craig et al., 2013a; Moharreri et al., 2013). As mentioned by the reviewer, the number of particles larger than 1 micron are sufficiently low that the exact upper cut-size of the inlets are not very critical. The lower cut-sizes of the two inlets should be similar, as the particle counters were identical, plumbing lengths were very similar, and sample flow rates were the same.

- "p. 2668, l. 21: I do not agree with this conclusion. Have a look at the right peak in Fig. 3. There are clear differences between BASE-I and SMAI, the latter inlet performing much better. Hence, please weaken you conclusion to something like "in principle the BASE-I design works, however, the uncertainties in the absolute numbers of interstitial aerosol particles are large." That's what I at least can see in this figure."

Author Response: We agree that, the conclusion should be weakened as suggested, and will make the change in the revised version.

- "p. 2669, l. 29: again, I believe the authors are too optimistic. The agreement between the measurements and the model results is not "excellent". What is shown in the figure is that a more realistic turbulence model changes the model results into the right direction, but the new model overdoes. But still this new model helps the

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authors to understand what is going on, so good to have these results. Please weaken the "excellent". And please indicate to the reader, why the model predicts the flow separation (i.e. that Cp becomes flat), not everybody is a CFD modeler."

Author Response: We will modify the wording to suggest that the agreement between modeling and measurements is now "improved" rather than "excellent".

The flat Cp region behind the blunt body housing indicates a large recirculation region with strong mixing where pressure and velocities are rather uniform along the surface of the body. This will be added in the revised text.

- "p. 2670, l. 5: do you have any idea about reasons for the pressure differences at different inlet sides? How does the vicinity of the inlet look like? By the way, could you provide a photo showing all three inlets at the aircraft?"

Author Response: The main reason for non-axisymmetric (i.e. 3-D) effects observed in the measurements is because of the presence of the aircraft skin and the strut connecting blunt body housing to the aircraft skin. As the size of the inlet is much smaller than the circumference of the body at the inlet location, the flow at the inlet location is uniform.

We had included a photo of the three inlets in Moharreri et. al (2013). We could mention this in the revised text.

- "p. 2670, l. 22: what does "range of normal velocities" mean? Please specify how large the range is and how this velocity range is distributed to the different particles sizes."

Author Response: Each line in Fig. 7 represents results for sampling efficiency of shatter particles as function of particle size and for a constant injection normal velocity. Text will be modified for clarification.

- "p. 2670, l. 25: most research aircraft fly at TAS larger than 100 m/s, how does Fig. 7 look if you include 150 m/s or even 200 m/s data? This should be easily calculated in

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FLUENT."

Author Response: The airspeed used in simulations for Fig. 7, corresponding to 400mbar and Ma 0.45 is $\sim$ 140 m/sec. Values reported in Fig. 7 (1 m/sec, 10 m/sec, and 100 m/sec) are the normal velocities used for injection of the particles at the surface of the blunt body housing, not the free stream air speed values.

At 200 m/sec the flow field around the blunt-body will be very different from that at 140 m/sec. At this higher Mach number, the flows will likely separate around the blunt-body, making this design ineffective for interstitial aerosol sampling at the higher aircraft speed.

- "p. 2671, l. 8: it took me a while to understand Fig. 8 because on the contrary to Fig. 1 and 2 the interstitial inlet is mounted downwards. Is it possible to mirror the two graphs? And I was always looking which cross section you show and where the solid line of the "Blunt body housing" comes from. Maybe it's easier to understand if you leave the solid line away here."

Author Response: Figures will be modified to keep the directions consistent and Fig. 8 will be modified as advised.

- "p. 2672, l. 19: you write that for "one selected set of sampling conditions… the two sets of size distributions match reasonable well", which would imply that the agreement is bad for all other conditions. What you likely mean is that "for any selected set of sampling conditions…" Or?"

Author Response: We selected a flight segment when we had clear air conditions with relatively constant flight parameters and all particle size measurement instruments used to generate the figure were functioning properly. While we expect a similar match in size distributions at all times, we did not explicitly confirm that. We will word it better in the revised text.

- "p. 2673, l. 3: there is a space missing in-between "at least""

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Author Response: We will correct the text.

- "p. 2673, l. 21: must be Fig. "12", not "2""

Author Response: Text will be corrected.

- "p. 2673, l. 25: how much lower are the BASE-II values? Please provide numbers."

Author Response: Equation for the linear fit will be added to provide quantitative measure.

Figures: "Fig. 1: caption, second line: must be "particles" not "inlets". And again, I do not believe that the scattered particles stay within the inlet boundary layer."

Author Response: Figure caption will be corrected.

"Fig. 2: please use SI units, i.e. at least "cm""

Author Response: SI units will be used.

"Fig. 5: please insert two times "model" in the legend after "k-"omega" SST""

Author Response: Figure legend will be modified as recommended.

"Fig. 6: please use SI units"

Author Response: SI units will be used.

"Fig. 10: please write "k-"omega" SST transitional model" instead of "simulations" in the legend"

Author Response: Legend will be modified.

"Fig. 11: please insert "Model" in front of "predicted sampling efficiency..." in the caption."

Author Response: Figure caption will be modified.

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