Atmos. Meas. Tech. Discuss., 7, C1295–C1301, 2014
www.atmos-meas-tech-discuss.net/7/C1295/2014/

Atmospheric Measurement Techniques
Discussions

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

A. Moharreri et al.

moharreri.a@gmail.com

Received and published: 11 June 2014

Reviewer Comment: Overview

"This manuscript builds on a series of published papers from the Clarkson group. The aim is perfection of aerosol inlets, making them less prone to produce aerosol particles that result from the breakup of hydrometeors, or avoidance of those particles. Because this manuscript is following others, there is a clear desire to make the point that the design/development/testing is a success. From everything I can see here, I am convinced that this is a valid conclusion. Having said that, I still have reservations; specifics are provided below.

What is the set and setting for this research? As I see it, the type of measurements

proposed (cloud interstitial), are fraught with hassle because of the largely unknown, and variable, effects of shatter. The Kleinman et al. paper (ACP, 12, 207-223, 2012) is a case in point. What did we learn from those interstitial measurements, how can this new technique improve on those studies, and what is the vision going forward? Related to this, I see the need for the development of observational tools, as described and improved on here, and for models which evaluate the myriad of processes (entrainment/mixing, Bergeron process, activation, and etc.) known to influence the budget of cloud interstitial aerosol particles. Without buy in, from modelers, I feel that this type of effort will wither. Clearly, that would be unfortunate."

Author Response: Prof. Snider raises an important point about the context of this research. While we agree that, in general, the best designed interstitial inlets will still experience variable and unknown shatter artifacts, our analysis presented in this submission and past published papers (Craig et al., 2013a and b) suggests that well-designed interstitial inlets should significantly minimize shatter artifacts under most conditions and possibly even provide shatter-free sampling under some conditions. The availability of such inlets, coupled with analysis such as those presented in Kleinman et al. (2012) will enable us to arrive at stronger conclusions about particle activation and help improve aerosol-cloud parameterizations.

The vision going forward is to make further improvements to BASE-II (particularly by increasing boundary layer suction flow) and have the inlet become part of the standard payload on the C-130 (and possibly other similar) aircraft. In addition, we believe that there should be at least two interstitial aerosol inlets of different designs in any field campaign – say BASE-II and SMAI. When measurements from these very different inlet designs are similar, then shatter-free sampling can be assumed (as shatter should be very strongly dependent on inlet geometry and flow conditions). Under such conditions, we can be confident about the accuracy of the physical and chemical measurements of interstitial aerosol made downstream of the inlet.

Reviewer Comment: "Much of my criticism stems from my own ignorance of the findings in Moharreri et al. (2013). The latter is a basis for this manuscript. I recommend that, in the introduction or later on, the authors summarize the relevant findings in the Moharreri et al. 2013 paper. I recommend this type of summary for the work of Craig et al. (2013a and 2013b), as well."

Author Response: We agree that the inclusion of summaries of past studies related to interstitial aerosol inlets would be appropriate. We will include a short summary of the three papers mentioned here to put our work in context of past work.

Specifics - "Figure 3 – The droplet concentration is about 70 cmˆ-3, so the interstitial aerosol would be expected to decrease by 70 cmˆ-3, relative to outside the cloud, if the inlet is excluding the cloud droplets, if shatter is minimal, and if the background (adjacent to the cloud) is representative of what entered the cloud through its base. I am surprised that there is not more discussion of these points. For example, the Figure shows an interstitial decrease (SMAI) (relative to outside) which is many times greater than 70 cmˆ-3. As I comment below, it would also be good to have the LWC and the drop-to-total mass ratio for this cloud pass, and as well for the other passes."

Author Response: Prof. Snider makes a pertinent observation about the discrepancy in the drop in aerosol concentration to the cloud concentration. There are several reasons for this discrepancy. One, there is a large variation between readings of different cloud probes during this sample time. During this cloud passage, cloud droplet concentrations from CDP were $\sim$ 70cmˆ-3, while the two FSSP-100 probes on the aircraft suggested concentrations of $\sim$ 230 and 310 cmˆ-3. The decrease in the BASE-I measurements are comparable to the FSSP measurements. The SMAI measurements see a decrease of $\sim$ 800-900 cmˆ-3, and this magnitude of decrease in aerosol concentration in the SMAI sample cannot be explained from the differing measurements of CDP and FSSP. The in-cloud interstitial aerosol concentrations should reflect the non-activated fraction of aerosol from the cloud base and it is quite likely that the out-of-cloud aerosol in this case did not represent the below-cloud aerosol concentration. For accurate aerosol mass/number balance, we would have to compare our in-cloud

measurements with below-cloud measurements, but that was not always possible during these campaigns (particularly during PLOWS).

We will add LWC and drop-to-total mass ratio for this cloud pass (and other passes).

- "P2668-L19-20 This phrasing is confusing: "..suggested that shatter particles in that size range will entrain the aerosol sample." It seems, to me, that the word "entrain" is being used to indicate something other than the entry of one fluid into another. I recommend that the authors elaborate on what it is that they are describing here."

Author Response: That sentence was meant to indicate that shatter particles of the mentioned size range enter the aerosol sample. This will be clarified in the revised manuscript.

- "The transition from Section 2.1.1 to 2.1.2 is abrupt. What is motivating the need for pressure measurements? In Section 2.1.2 you conclude that "..flow around the blunt-body separates." It's not clear what is implied by "separation" or how it is diagnosed from Figure 5. Does "separation" imply that even if the shatter particles are not ejected out of the boundary layer, they would be sampled?"

Author Response: The pressure measurements allow us to compare the nature of the actual flow field with those predicted by simulations. This will be better motivated in the revised manuscript.

Airflow around a blunt body may not follow the exact shape of the body and when this happens, i.e. when the flow "separates", a large wake region is created behind the body. In the wake region, the flow can be considered to be well mixed and hence particles near the body surface will no longer be separated from the sample flow. Thus, small shatter particles that were originally trapped near the wall could become available at the sample location.

- "Figure 6, when compared to Figure 5, looks like a mirror image. Why not present Figure 6 and Figure 5 similarly? Also, it is not clear if the hole, seen in Figure 1, allows air to flow down the centerline of the body."

Author Response: We will modify Fig 6 to match the orientation of Fig. 5 for consistency. The hole in the center of the body allows the air and particles to pass through the centerline and minimizes the available area for droplet impaction and hence shatter generation. This will be clarified when we add the summary of Moharreri et. al , 2013.

- "P2671-L4 In my opinion "..large droplet shatter.." should be replaced with "drop shatter." Further, I recommend that definitions be provided, up front, that follow the standard cloud physics definitions (cloud droplets<20 um radius and drops>20 um). See, for example, the Cloud physics textbook by Rogers and Yau."

Author Response: We will add definitions up front and, as recommended, we will replace "large droplet shatter" with 'drop shatter".

- "Figure 9 – The solid curve makes sense, but the dashed curve, defined in the caption as "..the size dependent fraction of shatter particles that will be present in the sampling flow region of cross flow sampling inlet" is not clear. I recommend that the latter be explained and discussed, in the text."

Author Response: We will better explain and discuss this in the revised text.

- "Figure 11 – It's not clear why the effect of the body (Figure 11a) causes the efficiency to exceed unity. Is the body acting like a CVI, causing the larger particle to concentrate? There is another thing about this. We need a diagram, or a statement, telling us that the UHSAS the HDDMA sampled from the BASE-II's sample inlet, and that the PCASP and F300 are open path and wing-mounted."

Author Response: The presence of blunt body causes the larger particles to concentrate in certain regions behind the blunt body. This effect is further explained in Moharreri et. al (2013) and should be clearer when we add a summary of that work in the revised manuscript.

It is explained in Page 2672 L14-19 that which instruments were connected to the

interstitial inlet sample and which instruments were wing-mounted. Similar text can be added to caption of Fig. 11b for further clarification.

- "P2672-L26 Presumably, drops, and droplets, coexisted in these warm cloud samples. Of relevance is the mass in these two hydrometeor size fractions. There are two products provided by NCAR. One is the drizzle water content (DWC), the other is the cloud water content (LWC). A useful statistic would be DWC / (DWC+LWC). I recommend that you report the DWC / (DWC+LWC), and the LWC, for this particular cloud segment and for the segments in Figures 3 and 4. Future researchers will need some grip on the cloud conditions you encountered."

Author Response: That's a good suggestion. We will report these parameters in the captions of Figures 3, 4, and 12.

- "P2673-L7 and L8 These lines describe what Craig et al. (2013b) did. Here, the BASE is compared to the SMAI (as a ratio, the "normalized enhancement"), without factoring in the ambient aerosol concentration. It's good that you are explaining what Craig et al. did. However, the transition to your "Normalized Enhancement" needs to warn the reader that you are not using the ambient aerosol as a reference. Related to this, the caption of Figure 12 uses "CN Enhancement" not the "Normalized Enhancement" used to label the plot."

Author Response: We will correct the caption in Fig. 12 and clarify that the SMAI concentrations are used as a basis to calculate the normalized enhancements.

"Other points

Adequate heating of the sampler, and of the slot, so that they do not clog with ice, will be a concern for future work. Specifically, where were the heaters installed? Also, was icing a problem? I understand that the suction flow is designed to keep the boundary layer attached. If the flow is turbulent, which it seems to be (Reynolds number $\sim$10ˆ6), then one might desire more suction than that provided in front of the sample inlet.

Have the authors considered a broader slot, perhaps circumscribing the perimeter of the body?"

Author Response: Four rod heaters spaced 45 degrees apart were inserted in holes drilled into the front side of the blunt body housing. An embedded sensor was used to monitor the temperature of the blunt body housing. During ICE-T, when we monitored temperatures, icing was not seen to be a problem. This information will be added in the revised text.

Author Response: We are, indeed, considering adding more boundary layer suction slots in a future design modification to minimize any turbulence in the boundary layer. A broader slot circumscribing the perimeter of the body might ensure a more axi-symmetric flow around the body, but will be practically difficult to implement, because of the challenges associated with drawing a significant flow from the body to the venturi pump.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 2663, 2014.