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Interactive Comment

Interactive comment on "Thermodynamic correction of particle concentrations measured by underwing probes on fast flying aircraft" *by* R. Weigel et al.

Anonymous Referee #2

Received and published: 13 January 2016

This paper proposes a new formulation for correction factor used in calculation of cloud particle concentration from data acquired by underwing cloud probes used on research aircraft. Focus of the work is on including effects of compressibility of the airflow around the probe housing on calculation of undisturbed ambient particle concentration. The article is well written and properly structured. The content is certainly relevant and significant to the atmospheric measurement community. However, following questions and comments – mostly related to the derivation of the correction factor formula - need to be addressed before I can recommend for acceptance of the manuscript:

Major Comments:

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1. My biggest concern about derivation of the new correction factor proposed in this manuscript is the assumption that the inertia of the particles is negligible, resulting in equations Vp=PAS and n/M=const in the text. Particle size range covered by the instruments mentioned in this work spans over more than two orders of magnitude which translates to more than four orders of magnitude in variation of particle relaxation time. It would be difficult to accept that particle inertia can be neglected for this entire size range. In fact, decreasing trend of aspect ratios in Figure 4 confirms that particle inertia becomes more important as particle size increases. It might be more accurate to assume Vp=PAS at the lower end of the size spectrum and Vp=TAS at the higher end (larger particles). Moreover, data presented in Figure 4 is only for particle diameters smaller than 350 microns, perhaps because data for >350 micron particles has been scarce. Without sufficient data, it is not clear how it was determined that the assumption of negligible particle inertia is valid especially for the larger particle sizes under study. Would an equation such as Belyaev and Levin (1974) or a similar correlation possibly developed for sub-isokinetic particle sampling in compressible flows provide a better estimate on enhancement of particles due to inertial effects?

2. Please include explanation or reference on how the probe air speed (PAS) was calculated. If the underlying assumption in this work is that the airflow around the probe is compressible, wouldn't temperature measurement be necessary for measuring the airspeed at the probe location also (Lenschow and Spyers-Duran, 1989)? If no temperature reading is available from the wing mounted probes and incompressible flow equation is used for calculation of airspeed, I suggest including a discussion on magnitude of the error introduced due to this simplification and clarification on what value was used for air density when calculating the velocity.

3. Eq. (8) shows the change in enthalpy for a constant-pressure process, which is not the case for the compression process between states 1 and 2. General form of the enthalpy change has a an additional term not shown in Eq. (8), e.g., dh = cp . dT + [v - T . (dv/dT)p] dp, where v is specific volume and (dv/dT)p is partial derivative at

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constant pressure. Why was the second term ignored in Eq. (8)?

Minor Comments:

1. Page 13430, L21-23 and Page 13431 L1-8 are difficult to follow. Please consider re-phrasing.

2. Page 13436, L17-23, this section seems to suggest that the advantage of the new method is in smaller uncertainty compared to method of using airspeed ratio. The issue here is not about the decreasing the uncertainty using the same input data, but the accuracy or rather correctness of the formulation used. Please consider rephrasing this section to avoid misleading conclusions.

3. I suggest eliminating "in" for the axis titles in the plots for better clarity, for example, replace "length of main image axis in um" with "length of main image axis, um"

References:

1. Lenschow, D. H. and Spyers-Duran, P., Bulletin 23, Measurement Techniques: Air Motion Sensing, NCAR Research Aviation Facility, 1989, https://www.eol.ucar.edu/raf/Bulletins/bulletin23.html

2. Belyaev, SP, Levin, LM, Techniques for collection of representative aerosol samples, Aerosol Science, 5: 325–338, 1974.

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 13423, 2015.

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