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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Flow-induced errors in airborne in-situ measurements of aerosols and clouds" *by* A. Spanu et al.

Anonymous Referee #1

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1 General Comments

This manuscript is a useful addition to the growing body of work investigating the influence of airborne particle instruments on the measurements that they are making. The most important aspect for me is the influence of Stokes number on particle velocity through the probe sample volume, this is nice. That said, I think that there are a couple of general and more specific issues that I would prefer to see addressed before publication.

The flow model includes the airframe, or possibly a section of wing and the canister plus pylon, and a hemispherical dome approximation of the probe. Some more details about how much of the aircraft is included in the model would be useful and if the flows at each of the four hard points are the same or different. No specifics are given for modelling the DC-8, it is unclear whether the flows at the probe location on the DC-8 shall be similar or the same as those on the Falcon. This is important as one of the conclusions relates to minimising the difference between TAS and PAS by judicious positioning of the probe on an aircraft.

The angle of attack (AOA) of the Falcon is briefly mentioned in section 2.1.2. It appears that the AOA is held constant for all flight conditions used in the simulations such that the orientation of the probe is always aligned with the local flow, or at least insofar as the error associated with the misalignment is negligible. Given that the simulations are done over a very large range of pressure and TAS and that an aircraft's AOA may be expected to change by degrees over this range, it would be useful to see some justification for this statement. No mention is made about these matters with regards to the DC-8 either.

This work appears to approximate the probes with a semi-hemispherical dome. It would be a significant addition (and an unreasonable request) to include the actual probe geometries. However a comment comparing this work to that of Weigel et al. (2016) and Korolev, Emery, and Creelman (2013), both already cited and which use accurate probe models, would be very interesting given the influence of the probe design on the local flow distortions and the apparent similarities in PAS/TAS ratios seen.

2 Specific Comments

More specific comments are included here. I have included the page.line number/s to assist although some of these comments may apply to multiple places in the text.

3.31 The manuscript uses 'airspeed' extensively throughout. It would be useful in the context of airborne measurements to clarify that true air speed is used as opposed to any of the other definitions used with regards to aircraft. TAS and PAS are defined later at 5.20. 'Speed' is mentioned in section 2.1 but this clarification may be introduced earlier if more convenient/coherent. See comment 7.22 below for more.

4.3 Air speed uncertainties are more relevant here than those in static pressure, can these be related to air speed errors for the range of conditions relevant to this work?

4.5 Are the uncertainties of the DC-8 MMS known? Are they comparable with those of the CMET?

4.30 In my opinion it is inaccurate to say that most probes have pitot tubes close to the sample volume. The DMT PIP- or CIP-based instruments do, the AIMMS does (although is less relevant as it does not measure all that close to particle instrument sample volumes), but (most/all?) other instruments do not. So actually the reverse of what is stated is the case. I'd suggest adding the importance of local PAS measurements to the conclusion of the manuscript with discussion about when it is most/least necessary based on what is being measured.

5.26 Positional errors are discussed throughout the manuscript and I found the usage confusing. Positional error, when defined in section 2.1.2, relates (as I read it) to the difference between TAS and PAS where TAS is the free stream air speed and PAS is the airspeed in the sample volume in the probe. However in 9.9 it seems that positional error possibly also refers to the difference between the air speed measured at the pitot on the probe and that at the sample volume of the probe (due to the difference in PAS measured by the long and short pitot tubes). However, there is no specific mention/quantification of the difference in air speed between the pitot and sample volume. Please clarify the usage if possible.

6.16 Does "simplified three-dimensional model" mean a hemispherical dome as shown in Fig 4? If so this is quite the simplification for a CAPS for example. So mention of expected uncertainties due to this simplification would be useful.

7.22 The use of ‘airspeed’ throughout is not as clear as it should be. In this sentence it is used to describe the velocity of a particle relative to the volume of air that contains it (slip velocity). Previously it has been used to describe the velocity of the aircraft and/or probe relative to the air. The difference is very important in this work so I suggest defining unique terms for consistent use throughout. TAS and PAS are traditionally used for the latter case so I’d suggest the use of slip velocity or some other term for the former.

8.23 Mention should be made to confirm if aircraft angle of attack changes with TAS in this model (here and elsewhere).

13.11 There is something missing in the description of the Vargas experimental set up which made interpretation difficult. It turned out that this is the fact that the droplet is ’dropped’ perpendicular to the plane of the rotating aerofoil and therefore has a velocity in that plane of zero when far from the aerofoil. An extra sentence to more fully describe the experiment that you are simulating would be useful. Also suggest using slip velocity instead of U_{rel} as this is a commonly known term. How is ‘breakup’ that occurs around 60 ms^{-1} defined/identified given that the images in figure 14 contain only a single particle?

14.10 It is not obvious to me why the varying slip velocity case is different from the invariant one. An explanation would be appreciated.

17.4 VOF has not been defined previously.

17.5 Has there been discussion about “wiggling” behaviour previously? More specific language is required here.

17.6 Have Taylor instabilities been discussed previously?

3 Technical Corrections

There are quite a few basic notation inconsistencies, spelling mistakes, and technical errors that make following the text difficult and detract from the quality of the manuscript. Below are listed the technical corrections that I have caught, given as page.line numbers.

3.32 “per default” is quite an odd expression. “By default” would be more typical although in this instance I think the sentence makes sense without either, ie “The DLR Falcon is equipped with a...”

4.3 Does “pilot-induced manoeuvres” mean turns but not fluctuations due to autopilot corrections or turbulence? Clarification of this phrase would be helpful.

4.19 Is “composed instrument” supposed to read “compound instrument”?

4.21 A OAP does not measure diameter directly, the user/software determines the size from the image recorded by the array. Different size metrics are defined in section 3.2.2 and so could be referred to here.

4.23 I’m not sure what is meant by “named shutter speed of the camera”.

4.24 The SID is a scattering instrument not an OAP so should be removed from this list.

5.19 It seems as if “attack angle” here is used in reference to the alignment of the probe to the local air flow. This is confusing as “angle of attack” is traditionally used in reference to the alignment of the aircraft to the air flow (and indeed appears to be used in this way in 5.16). This should be clarified.

5.21 I’d prefer that “measured” is removed as the PAS is the airspeed at the probe location whether it is measured or not.

6.16 Change PMS and add canister to sentence to read "...Particle Measurement Systems canister..."

6.21 Do you have a reference for snappyhexmesh?

6.24 There is some confusing notation regarding U, ***U***, and U. The usage should be consistent, particularly between the italic and upright versions. One can reasonably assume that U_0 is defined along the free stream direction given $|\boldsymbol{U}_0| =$ TAS but an explicit definition of the axes along with consistent nomenclature would make this is clearer.

7.13 Change "as" to "an".

7.16 Change "model including..." to "model to include...".

7.17 Change "not fully agrees..." to "does not fully agree...".

7.27 I'm not sure what is meant by "...both in the spatial and temporal discretization". Should "in" be replaced by "with"?

8.26 This sentence uses upright U, should they be italic?

9.3 The sentence starting "The simulation results refer to..." is unclear. Is this "The figure refers to..." or "The simulation results are relative to..." or something else?

9.9 See discussion on positional errors in the previous section but in this sentence it would be useful to know why and how the longer pitot tube effects to positional error. This shall assist in understanding the uncertainties when applying the methods discussed to instruments with different pitot tubes or even using pitot tubes mounted near a probe but not as part of the instrument.

9.17 Typo in "However".

10.9 The test case u100_p900 is not actually included in Figure 8.

11.16 Specify which air speed you are referring to here.

12.18 It may be pedantic but Figure 12 shows circular images (which admittedly one assumes are of spherical drops).

12.23 The x and y dimensions should be defined in terms the array and with time (in terms of which the image is described in 12.16) so that the reader understands the aspect ratio values. This is clarified in 13.1 but should be brought forward to this point.

12.24 The markers in Figure 13 are not black.

14.3 The symbol for Weber number should be italics so that it is more obvious in text.

15.1 Add what threshold value you have used in your greyscale images when finding image area.

18.22 This is cited (incorrectly) in the body as Osborne and Cotton. The full author list is required here.

45.6 The data DOI needs updating.

Comments on figures:

Fig 2 Many of the figures are shaded by number of seconds, for clarity it would be useful to add "...number of seconds of data at ?? Hz."

Fig 4 The free stream flow should be marked on this plot. There is some confusion regarding the orientation of the flows in the model between figures 4, 5, and 7. In figure 4, if the free stream is oriented with the figure then it appears as if the angle of attack (AOA) of the aircraft is not accounted for and the probe is not aligned with the flow. In figure 5, the free stream is aligned with the probe and so the AOA has been accounted for, however for the given flight conditions I assume that the AOA is changing and this is not mentioned (see previous comments regarding AOA). In figure 7, the free stream seems to be coming up to the probe from below (which is opposite to the case shown in figure 4) or perhaps aligned with the probe, it is difficult to tell.

Fig 5 The pitot tube seems to be located diagonally off centre from the dome. Does the schematic represent where the pressure/velocity was measured or was it measured in front of the stagnation point of the dome (I assume that this is where the sample volume is)?

Fig 7 It would be useful to use the same colour scale parameters in this figure as in figure 4. When I converted from ratio to difference the values appear inconsistent between these two figures, is this an issue with my maths/understanding of what is being presented or an actual inconsistency between the two plots?

Fig 13 The main text and caption refer to black markers, maybe it's my display/print but there doesn't appear to be any black markers. The A-LIFE and ATom-2 data have similar shades of grey, completely different colours would be significantly clearer. Is there a reason that the red trace, the mean for the ATom-1 data does not approach unity for small particles?

Fig 16 There appears to be multiple data points for the same TAS values (most evident for 125 ms^{-1}), is this a plotting error or does it illustrate the different test cases? If the latter it should be mentioned that P and T don't make a lot of difference.

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Discussion paper