

# ***Interactive comment on “The Universal Cloud and Aerosol Sounding System (UCASS): a low-cost miniature optical particle counter for use in dropsonde or balloon-borne sounding systems” by Helen R. Smith et al.***

**Helen R. Smith et al.**

h.smith20@herts.ac.uk

Received and published: 2 June 2019

responses are shown under reviewer comments

Response to reviewer #3

Major comments Sections 3.1 and 3.2 show intercomparisons with a PCASP and a CDP respectively. The subject of this paper is an instrument which counts and sizes airborne particles, so it is confusing that the comparisons with other counting and sizing instruments is accomplished using data which has been converted to mass per unit

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volume. Especially given the motivations outlined in section 1 to improve understanding of aerosol radiative direct and indirect effects which are in large part controlled by particle number and surface area rather than mass. It can be difficult to compare three dimensional plots of size distribution as a function of time or height. However, it would be useful to see at least either a time series of particle number alongside the mass time series, or an averaged size distribution for UCASS and PCASP / UCASS and CDP in sections 3.1 and 3.2. This would improve confidence in the sample volume calculation outlined in section 2.5 as well as in the sizing accuracy of UCASS.

response: Some of this comparative data is used simply because this was the data made available to us. But this is a good suggestion, I will have a look at the available data and try to implement this where possible.

Minor comments Section 2.1 Figure 2 uses a different but similar looking labeling system to Figure 1. It might be worth numbering the parts in one of these diagrams, although this change is not essential. Figure 2 also appears to be less well drawn than the other figures in section 2. It might be worth tidying it up.

response: I will change the labelling system so that it is consistent for the whole section. I will also redo figure 2

Section 2.2 This section should possibly have some reference to dealing with coincidence errors or at least an estimate of the number concentration at which coincidence errors are likely to become significant.

response: I will add in an estimate for this

Section 2.3 Line 3 on page 9 and subsequent parts of the paper contain references to 4095 bins of amplitude displacement. This is initially a bit confusing because in this context the output of a voltage converter as described is (very) often referred to as "Analogue to Digital Counts" or AD counts. P9 L8 - It would be interesting to know why such a large range of particle time of flight is accepted. P12 L10 Typo: none-

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turbulent should be non-turbulent. See also P14 L4 (none linearity), P19 L12 (none cloudy) and others.

response: You may be correct about the AD meaning, I will check and correct it if necessary. Particle time of flight is related somewhat to the particle size, although there is realistically a large spread in ToF. The boundaries are set to remove unrealistic values of ToF based on empirical data. I may add more about this in the manuscript as reviewer #1 had some questions about ToF too. Typos will be corrected

Section 2.4.2 Presumably the sheath flow was added in order to accommodate the large volume of air flowing through the instrument. It would be useful to state this. It would also be interesting to know the length of the dryer column. A flow velocity of 5 m/s might not provide sufficient time to dry a flow containing PSLs using most conventional dryers. On page 13 line 6 the authors discuss the use of PbP data to eliminate bin width related artefacts. They appear to be writing about exactly the same measures they describe in section 2.3 (page 9 line 3), but using completely different terminology. This is confusing. PbP pulse height recording is a more widely understood terminology than that used in section 2.3 so it would be useful to standardise to this. Figure 8 has  $f(x)$  as the Y axis label. This is normalised counts, but is not defined in the text or the figure legend. Figure 9 on page 15 shows an additional step in the probe calibration relating scattering cross section to instrument response. It is more usual to see the calibration mode diameters plotted on top of the Mie curves as presented in figure 10. It would be useful to see the calibration added to figure 10 as well as (or even instead of) figure 9.

response: You are correct in that the sheath flow is used due to the large volume of air being used, it is essentially used to constrain particles within the middle of the air flow allowing for fewer beads to be used. I will add in the length of the tube. The wet dispersed aerosol (PSL) are passed into the tube from another drying chamber before they enter the tube. I will clarify this in the revised manuscript. I will update the terminology as suggested to 'PbP pulse height recording'.  $f(x)$  is the probability density

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function, I will define this in the text and caption. I think it is important to keep figure 9 to show the relationship with cross section, as this can be applied to any particle and is therefore useful in post calibrations. I will add the calibration particle information on figure 10 as suggested.

Section 2.5 More description about how the angles of oscillation were calculated would be interesting. Also, on line 2 of page 18 the authors give an airspeed of  $5.4 \pm 0.3$  m/s. Reading the values for  $\pm 5$  degrees from figure 11 seems to show a range of around 4.5 to 5.6 m/s. The authors should show how the former figure was arrived at.

response: The description of the pendulum system was not initially included for reasons of brevity, however this may be added as an appendix. The 'range' in airspeed is actually standard deviation, not a range, I will clarify this in the text (and also reconsider if this is the best way to describe the air flow).

Section 3 Figure 14 would be much easier to interpret if panels a - c used the same Y scale.

response: Good suggestion, I will correct this.

Section 3.1.2 The explanation of the differences between the UCASS and PCASP measurements sounds a little speculative. It raises a question about why these data are being used for an intercomparison if their imperfect collocation means they are not comparable. The agreement between the probes seems OK, so this could be left out (major comment above being addressed). P22 - Figure 16 appears to be at insufficiently high resolution or has been compressed using an excessively "lossy" method. Can this be re-plotted?

response: The use of field data is really intended to highlight the various uses of the UCASS and show (albeit speculatively) how it can be used to complement campaign datasets and potentially be used as an alternative where flights may not be possible. It is not intended as controlled proof of the instrument performance. Due to the additional

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laboratory tests suggested by the other reviewers, I will try and make this clearer in the revised manuscript. i.e. laboratory data for intercomparison, field data for examples of use. Fig 16 will be redone.

Section 3.2 Change "Figure ???" to Figure 17 on the first line of page 23. The discussion on page 23 of the time of flight rejection causing under counting contains a mistake. The short time of flight of fast moving particles is rejected on the basis that it looks like short duration electronic noise, not on the basis that it looks like a large aggregate particle. At least according to the reasoning in section 2.3 (page 9).

response: The 'figure ???' typo will be corrected. Also, the incorrect description of short ToF rejection will be rejected.

Section 4 Line 8 of page 25 mentions the use of an 8+ point sizing calibration. Was this type of calibration applied to all probes contributing data in section 3, or was this done once as an instrument characterisation exercise?

response: This was done as an instrument calibration exercise as more calibration standards have been made available since the first field tests were done. I will clarify this in the text and explain the calibration used for previous launches.

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2019-70, 2019.