We thank Professor Darrel Baumgardner for his review our AMTD manuscript (Cai et al., 2013; C2013). Baumgardner asserts that our PCASP size calibration has little relevance to investigations of atmospheric aerosols. Specifically, Baumgardner contends that the diameter shifts we report, for polystyrene latex (PSL) test particles, are small relative to the shifts due to variation of particle refractive index. Herein we conclude that Baumgardner's assertion is overstated.

Our empirically-based diameter shifts are evident in Tables 1 and 2 (C2013). Expressed as a relative shift, and ranked from smallest to largest, these are as large as 0.01 parts in 0.14 (7%) (mid-gain), 0.02 parts in 0.10 (20%) (high-gain) and 0.14 parts in 0.34 (41%) (low-gain).

In C2013 we speculated that changes to the PCASP optical system, through time, were responsible for the diameter shifts we documented. Calculations in Rosenberg et al. (2012) (R2012) support this speculation. We refer the reader to the left panel of Figure 9 (R2012). Here the Rosenberg et al. examine the effect of moving the sample/laser intersection point along the laser axis. For the range of particle diameter in Baumgardner's critique of C2013 (0.3 μm to 0.5 μm), the relative variation of particle size, evaluated at fixed crossection, is ~ 10%. Indeed, Rosenberg's calculation establishes that a reasonable variation of the scattering geometry can induce shifts of PCASP-derived particle diameter comparable to the diameter shifts we documented in C2013.

Now we compare the diameter shifts in C2013 (7% to 41%), and in R2012 (~ 10%), with those predicted by Baumgardner's refractive index model. For the latter we consider a particle composed of sulfate and black carbon and compare its actual diameter to that derived using a PSL-calibrated PCASP. The diameter shift is 0.04 parts in 0.30 (13%) (0.34 μm sulfate/BC particle) and 0.10 parts in 0.40 (25%) (0.50 μm sulfate/BC particle). We see that our empirically-based diameter shifts (7% to 41%; C2013) and the shifts documented in R2012 (~ 10%; their Figure 9) are comparable to the shifts due to variation of refractive index (13% to 25%). Also, we note that this assessment contradicts Baumgardner's critique of C2013 where he contends that "The evaluation avoids the more relevant issue and that is that we don't measure PSLs in the atmosphere so that the very small shifts in the sizing calibration curve have not made any real improvement in the accuracy of the sizing." In support of our conclusion we note that Liu et al. (1992) showed that PCASP sizing of PSL particles differed by as much as 25% from the manufacturer's recommendation.

Baumgardner also comments that the paper by Pinnick et al. (2000) supports his conclusion that sensitivity to refractive index dominates our correction of the manufacturer-recommended sizing. We don't read it that way, rather, we note that Pinnick et al. were emphatic in their recognition that models of scattering require empirical backup: "Again, we emphasize that a single normalization factor for each probe was determined by doing a weighted fit of the polystyrene latex measurements to the theoretical response", Pinnick et al. (2000).

Finally, we are puzzled by Baumgardner's comment that "…there will be particles larger than 0.35 μm but less than 0.5 μm that will likely get lost if they fail to exceed the minimum ACD threshold of the low gain." It is our finding that particles may be assigned to an incorrect PCASP channel, depending on the particular setting of the baseline reference voltage (C2013), but we have no evidence that particles are being "lost." If this effect was substantial it would be an alarming revelation to the folks that have conducted the many successful optical closure studies using a PCASP.

In summary, we return to what we said in response to Dr. Rosenberg's evaluation of C2013: "Our size-calibration method derives an offset for each of the probe's three gain stages. This represents a relatively simple first-order correction for particle sizing performed by the PCASP. Motivating this is the requirement that we deploy aircraft instrumentation whose laboratory-response characteristics are documented, that we provide a correction to the manufacturer's calibration, when needed, and that we provide a history for each deployment."

References -

Cai, Y., J.R. Snider and P. Wechsler, Calibration of the passive cavity aerosol spectrometer probe for airborne determination of the size distribution, Atmos. Meas. Tech. Discuss., 6, 4123-4152, 2013

Liu, P. S. K., Leaitch, W. R., Strapp, J. W., and Wasey, M. A.: Response of Particle Measuring Systems airborne ASASP and PCASP to NaCl and latex particles, Aerosol Sci. Technol., 16, 83-95, 1992

Pinnick, R.G., J.D.Pendleton and G.Videen, Response characteristics of the Particle Measuring Systems Active Scattering Aerosol Spectrometer Probes, Aerosol Science and Technology, 33, 334-352, 2000

Rosenberg, P. D., Dean, A. R., Williams, P. I., Dorsey, J. R., Minikin, A., Pickering, M. A., and Petzold, A., Particle sizing calibration with refractive index correction for light scattering optical particle counters and impacts upon PCASP and CDP data collected during the Fennec campaign, Atmos. Meas. Tech., 5, 1147-1163, 2012

We thank Reviewer-1 for this careful review our AMTD manuscript.

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p.4125. L2. Diameter plural. Insert that after diameters.
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Change made.

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p. 4129. L8. Flight plural.
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Change made.

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L11. Add ed to conduct

L12. Are to were

L14. Is to are

L18. Though for different sizes

L22. Variation plural.

L26. Not the last column but the sixth column

L28. Is this shown in Table 1?
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We have reflected on these comments. Here is our corrected version of the three critiqued paragraphs:

After establishing the flowrate calibration, we verified that the PCASP reports a very small concentration (< 5 cm^{-3}) while sampling filtered air. Also, we conducted tests with the PCASP operating in parallel with the CPC while both were sampling electrostatically-classified PSL spheres. Results from one test are illustrated in Figs. 2a, b. Here the "plateaus" correspond to electrostatically-classified PSL spheres, and the "valleys" to periods when we were switching the PSL hydrosol. We note that there is good agreement between the CPC- and PCASP-derived concentrations, over a range extending from 40 cm^{-3} to 460 cm^{-3}, and that the concentration variability is larger for the PCASP. We also note that these tests evaluated four samples of mobility-selected PSL particles and that concentration varied inversely with particle size.

We find that the concentration variability, expressed as a standard deviation, is four times larger for the PCASP compared to the CPC (Fig. 2b). Moreover, we note that the concentration variability is consistent with variations attributable to the different aerosol flowrates in these instruments and Poisson counting error. This assertion is substantiated in Appendix A.

Table 1 summarizes aerosol flowrate calibrations we obtained for several King Air projects, for both PCASP-1 and PCASP-2. The sixth column has the flowrates for different calibrations evaluated at a fixed flow sensor signal voltage (2.7 V). Relative to measurements made in

2006 (PCASP-1) and in 2010 (PCASP-2), the maximum shifts of the calibrations are 6% and 18%, respectively.

p. 4131. L12. A calibration does not produce. It indicates. The word increase implies time, i.e., growth, which is not the case here. This is merely a comparison that is independent of time. The laboratory calibration shows sizes that are larger or smaller than the manufacturer calibration.

L13-14. This does not make sense. Why not just compare the same rows of the two columns as they are written? There is no 0.30 or 0.28 or 0.40 in the last column and there is no 0.27, 0.29 or 0.34 in the column before the last column.

L14-15. This is not evident in Table 1. Please explain.

L16-17. Note row 6 of Table 1.

We have reflected on these comments. Confusion seems to have resulted because we did not specify the columns of Table 2 with the relevant diameters. Here is our corrected version of the two critiqued paragraphs:

For the mid-gain and low-gain channels (Figs. 3b and 3c), we find that the manufacturer's calibration (dotted black line connecting diamonds) does not precisely define the PSL sphere diameter. The derived diameter shifts are ΔD=0.00 µm (high gain), ΔD= -0.01 µm (mid gain) and ΔD= -0.06 µm (low gain). Our most recent determination of the calibrated threshold-diameter for PCASP-1 is provided in Table 2.

Results presented in the final column of Table 2 demonstrate that the most recent PCASP-1 calibration has a positive increment from the diameter of the last channel of the mid-gain stage (0.29 µm) to the diameter of the first channel of the low-gain stage (0.34 µm). A positive increment at this particular gain boundary is evident for all of our calibrations (result not shown). For the particular case – the most recent PCASP-1 calibration - this can be verified by adding the manufacturer's diameters at channels #14 and #15 (0.30 µm and 0.40 µm; Table 2) to the mid- and low-gain shifts (-0.01 µm and -0.06 µm) from the fifth row of Table 1.

L18. There is no diameter increase. There is a difference between the manufacturer and the laboratory calibration.

L22. Evaluate is not the best word. Indicate would be better.

L23. Explain reversal.

We have reflected on these comments. Here is our corrected version of the critiqued paragraph:

In contrast to the positive increment at the mid- to low-gain boundary, our calibration produces ambiguity at the high- to mid-gain boundary. This is made evident both in the last column of Table 2 (Calibrated Diameter), and in Figs. 3a and 3b. In the table, and in the two figures, the calibrated diameter of the last channel of the high-gain stage and the first channel of the mid-gain stage both indicate 0.14 µm. At this gain stage boundary, a sizing overlap, or even a sizing reversal occurs. In the case of the PCASP-1 in the CUPIDO project the reversal can be verified by adding the manufacturer's diameters at channels #4 and #5 (0.14 µm and 0.15 µm; Table 2) to the high- and mid-gain shifts (0.02 µm and -0.01 µm) from the second row of Table 1.

P4134. L22. Is to was.

No change made.

P4135. L8. Former to non-spherical.

L9. Latter to spherical. Former and latter do not same that much space.

We have reflected on these comments. Here is our corrected version of the critiqued paragraph:

Using scattering phase functions reported by Mishchenko et al. (1997), Collins et al. concluded that the sizing difference, for a non-spherical versus a sphere-equivalent particle, would be 5% with the non-spherical sizing smaller than the spherical.

P4137. L5. Shift plural.

Change made.

L7. Size plural.

No change made.

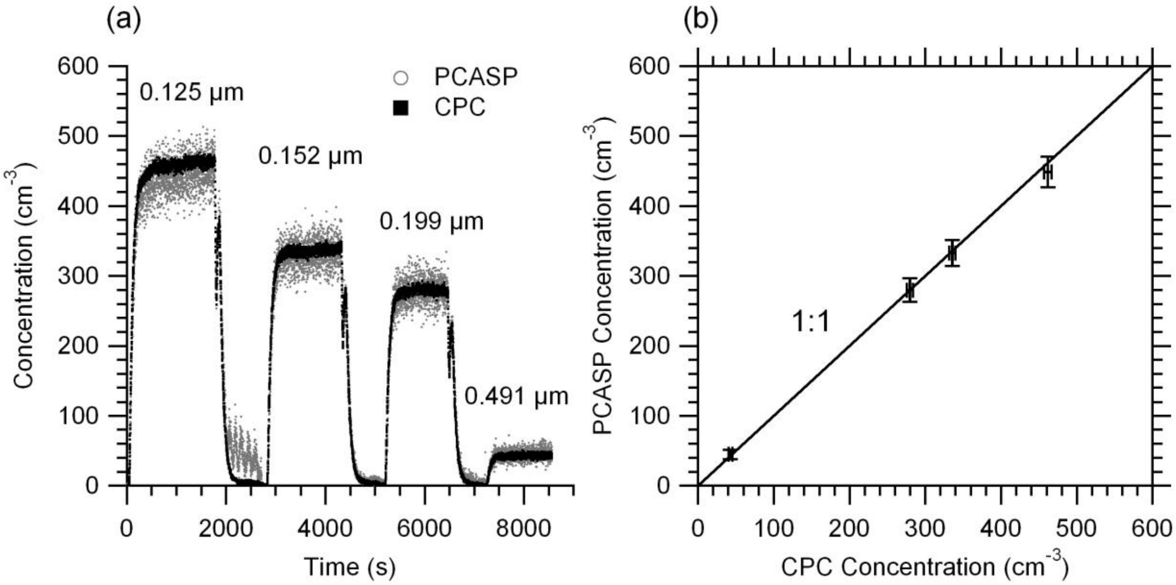
P4145. Threshold units?

The following footnote was added:

[a] The thirty thresholds are internal electronic representations of the channel boundaries. A digitized pulse height is compared to the thresholds to infer the channel a particle is classified into.

P4149. No a or b in fig. Maybe not necessary?

Change made; see next page.


(a)
0.125 µm
0.152 µm
0.199 µm
0.491 µm
PCASP
CPC
Concentration (cm^-3)
Time (s)
(b)
1:1
PCASP Concentration (cm^-3)
CPC Concentration (cm^-3)

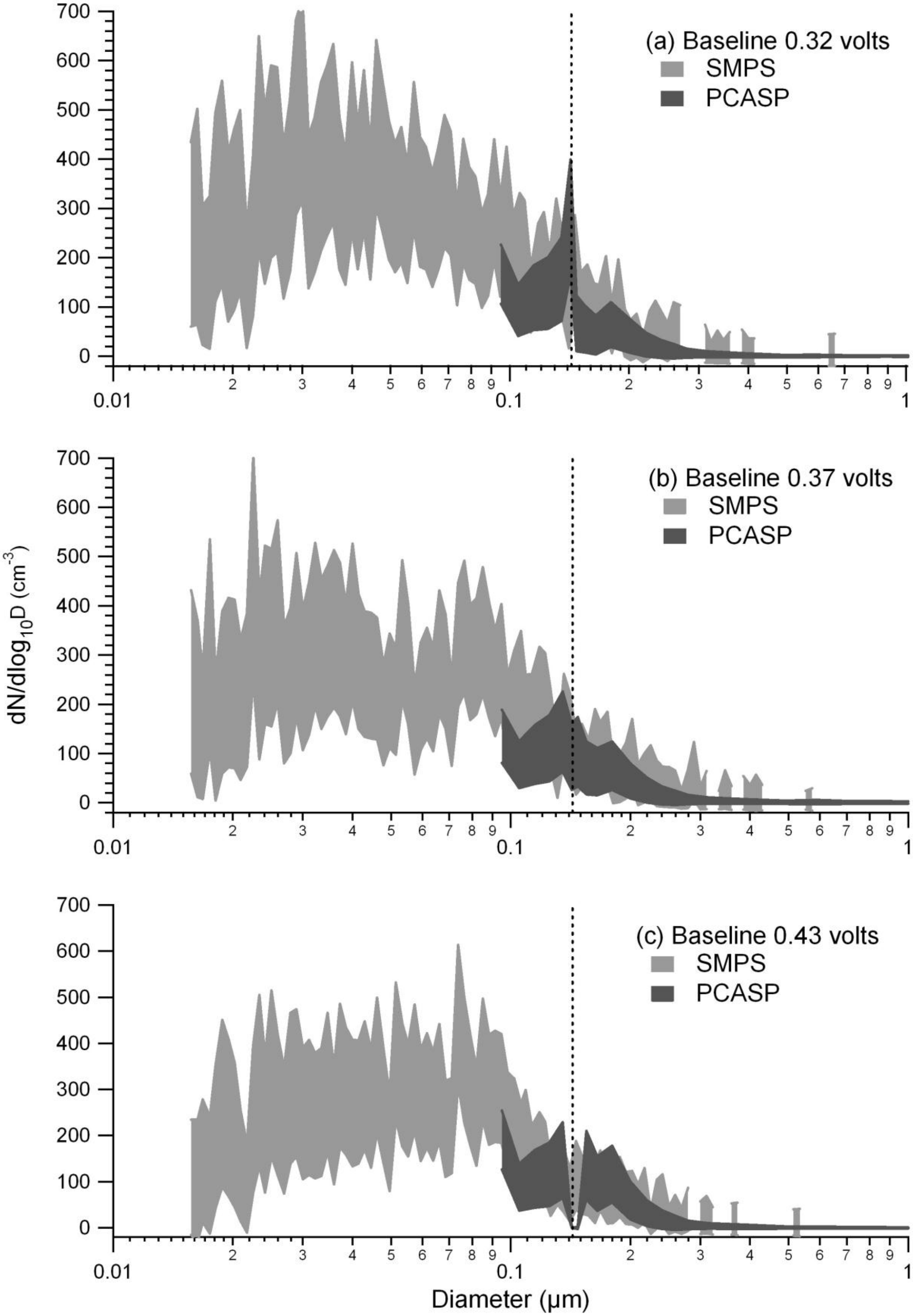
P4150. Threshold units?

The following was added to the figure caption:

The thirty thresholds are internal electronic representations of the channel boundaries.

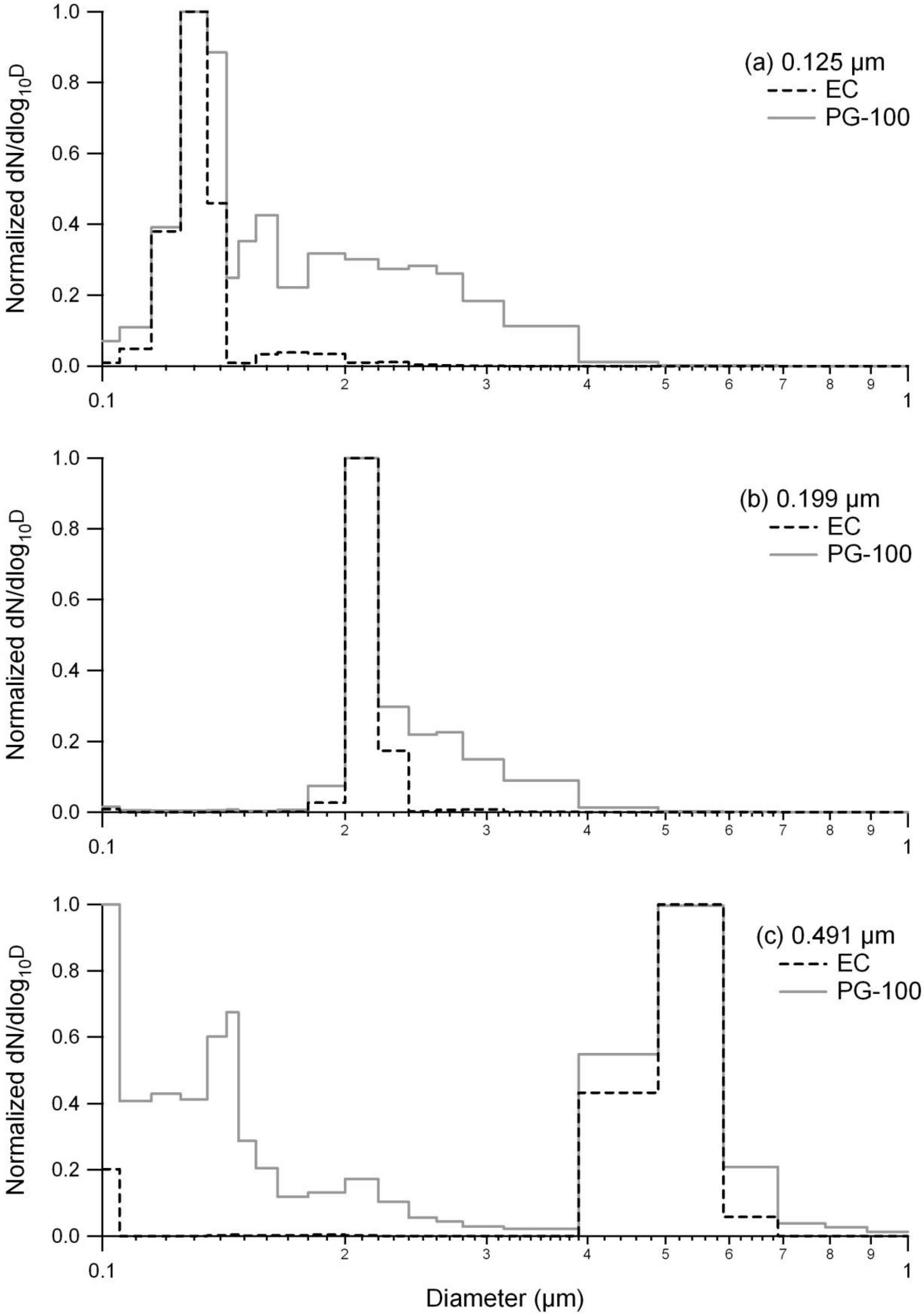
P4151. No a, b or c on fig.

Change made; see next page.


(a) Baseline 0.32 volts
SMPS
PCASP
(b) Baseline 0.37 volts
SMPS
PCASP
(c) Baseline 0.43 volts
SMPS
PCASP
dN/dlog10D (cm-3)
Diameter (µm)
0.01
0.1
1

P4152. No a, b or c on fig.

Change made; see next page.



(a) 0.125 µm
EC
PG-100
(b) 0.199 µm
EC
PG-100
(c) 0.491 µm
EC
PG-100
Normalized dN/dlog$_{10}$D
0.0
0.2
0.4
0.6
0.8
1.0
0.1
2
3
4
5
6
7
8
9
1
Diameter (µm)