We would like to thank the reviewers for their clear and positive reviews. We have addressed comments below. Our responses are in blue. Changes to the manuscript text where needed are noted in red.

Some things to alert reviewer to:

Abstract is slightly rearranged and has some new text reflecting changes in the manuscript.

We have made some very minor updates to the text to add a clarifying word or sentence in places. These changes are noted in red in the text. We have also made some minor adjustments to some of the figures (e.g., changed um to µm on axes labels).

Added 2 new sections:

- Section 5.2.2 "Predicted aerosol size truncation versus published laboratory data" applies the approach shown in original Sect. 5.2.2 (which is now Sect. 5.2.3) for BOS field observations to laboratory results reported in the literature. This section uses much of the text of the original Sect. 5.2.2 but adds discussion related to comparison with published laboratory results. This section contains a new figure - Fig. 10 in revised manuscript - comparing laboratory observations from literature to our model. Also addresses comment #4.
- Section 5.2.7 "Relationship between CH1 and $PM_{2.5}$" breaks out the brief discussion of this relationship in the original Sect. 5.2.5 and slightly expands it to tie it to mass scattering efficiency information. Also addresses comment #8.

Added cited references to end of supplement.

Reviewer #2

The paper “Evaluating the PurpleAir monitor as an aerosol light scattering instrument” by Ouimette et al, examines the possibility of using Purple Air PMS sensor data to determine integrated aerosol light scattering coefficient. A model considering Mie theory and the sensor geometry is used to predict light scattering signals expected from the sensor and the forward and backward scattering truncation. The model is used predict sensor performance as a function of particle size and the results confirm that the sensor does not measure size distributions. And that the signal is proportional to scattering coefficient.

The paper presents a comprehensive picture of the working of PMS5003. The sensor details, model results and experimental validation adds to the existing knowledge on PMS 5003 and critically confirms findings of other studies that have concluded that the sensor behaves more like a nephelometer rather than a scattering spectrometer. The paper is well written and its findings are likely to be very useful to the growing community of scientists using these sensors for air quality measurements.

I have minor points for the authors to consider.

(1) Lines 106-108 – "is of light scattered by particles (Kelly et al., 2017) which traditionally has been … using integrating nephelometers". This sentence should be reworded. As it reads currently, it seems like light scattering measurements are only made by nephelometers.

Yes, you are right. There are many instruments that use light scattering, such as the Teledyne T640x for FEM PM2.5 and optical particle counters, which use light scattering at discrete angles to derive other particle properties such as mass concentration and size distribution.

We have added the text in red to clarify:

The actual measurement in the PA monitor with its two PMS5003 sensors (PA-PMS), and in many other low-cost aerosol monitors, is of light scattered by particles integrated over a wide range of angles (Kelly et al., 2017), which has traditionally been done in atmospheric research and aerosol monitoring programs using integrating nephelometers.

(2) Lines 137-139. "Model predictions are then compared with yearlong field data at NOAA's Mauna Loa Observatory …". Please clarify exactly what predictions are compared with what data.

We have clarified the sentence to say that both model predictions and PMS observations are compared with measurements of aerosol light scattering (at MLO and BOS) and also with measurements of aerosol size distribution (at BOS). The sentence now reads as

PA-PMS measurements are compared to yearlong measured aerosol light scattering coefficients at NOAA's Mauna Loa Observatory (MLO) in Hawaii and to measured and modeled aerosol light scattering coefficients and aerosol size distribution at the Boulder Table Mountain (BOS) site in Colorado.

(3) Lines 140-141: "… an empirical relationship is developed to estimate the light scattering and uncertainty from the PA-PMS data." Light scattering intensity? And uncertainty of what?

We have clarified the sentence as follows:

Finally, an empirical relationship is developed to estimate the submicron light scattering coefficient and its uncertainty from the PA-PMS data.

(4) How is the uncertainty in the physical geometry and optical geometry accounted for in the model?

The originally submitted manuscript did not include how the uncertainty in the physical geometry and optical geometry is accounted for in the model. The revised paper now includes this uncertainty in geometry on model predictions in a new table - Table S3 (pasted

below). We have added the following text in Sect. 3.3 and Sect. 5.2.1 to further address this:

The variance in the PMS physical and optical geometry and errors in the measurements are not known but likely small. To evaluate the sensitivity of the modeled PA scattering to errors in these measurements, the model was exercised with large deviations of ±25% and ±50% in these inputs. As shown in Table S3, the errors tend to increase with particle size. The modeled PA scattering to a perfect nephelometer is most sensitive to errors in the distance from the laser to the photodiode. For particle diameters of 0.5 μm, +25% and +50% changes in this distance resulted in maximum differences of 10% and 20%, respectively. Based on these results and the fact that the errors in the physical dimensions are less than 25%, these errors are thought to have a small contribution to the overall modeled PA scattering error and were not directly accounted for in the analysis. This analysis does not attempt to account for the possibility that the laser beam profile is not a simple plane wave or that the laser beam profile may evolve significantly as it is focused over the photodiode, and the standard plane wave Mie calculations would no longer apply.

Table S3 added to Sect. S4:

Table S3. Effect of uncertainty in measurement of the PMS geometry on model predictions of scattering ratio compared to a perfect nephelometer as a function of particle diameter. The % changes in various dimensions (left most column) are compared to the base case predictions. The base case dimensions are in Sect. 2.2.4, and the base case predictions are on Fig. 7.

Particle diameter (μm)	0.30	0.50	0.70	1.0	2.0	4.0
Scattering ratio for the base case geometry	0.88	0.55	0.38	0.31	0.22	0.23
Change in distance from laser to photodiode (%)	Percent change in scattering ratio compared to base case					
-50	-3	4	26	42	39	26
-25	0	7	20	24	13	15
25	-2	-10	-21	-17	-4	-10
50	-3	-20	-36	-26	-10	-21
Change in diameter of exposed photodiode (%)	Percent change in scattering ratio compared to base case					
-50	-4	-10	-26	-14	-7	-12
-25	-2	-5	-10	-9	-4	-4
25	1	4	8	9	4	5
50	2	6	13	16	8	9
Change in distance of laser exit hole to photodiode (%)	Percent change in scattering ratio compared to base case					
-50	-2	-8	-25	-19	-2	-8

-25	-2	-2	-7	-11	0	-3
25	0	-7	-2	2	-3	-4
50	0	-12	-5	3	-4	-6
Change in thickness of base mask over the photodiode (%)	Percent change in scattering ratio compared to base case					
-50	1	2	1	0	3	1
-25	0	1	1	0	1	1
25	-1	-2	-1	-1	-2	-2
50	-1	-5	-4	-3	-5	-5
Change in distance from photodiode to light trap (%)	Percent change in scattering ratio compared to base case					
-25	3	3	3	3	-2	1
-50	1	1	1	1	-2	0
-75	3	3	3	3	-2	1

Additionally we have added the following text to Sect. 5.2.1:

The predicted photodiode output is linearly correlated with the ordinary least squares (OLS) regression ($R^2 = 0.90$, normalized root mean square error (NRMSE) ~25%) with CH1 over 4 orders of magnitude. The RMSE contains contributions of errors from the model-predicted radiant power, the measured SMPS data the model is based on, as well as in the CH1 measurements. This strong correlation and low RMSE is convincing evidence that the model and SMPS data describe the PMS response quite well.

(5) In Figure 2, the precision is shown as a function of concentration. How much of the decrease in precision with decreasing concentrations can be explained by Poisson statistics of number of particles expected in the viewing volume of the units?

We have added the following text in Sect. 2.2.9 to address this comment:

There are two mechanisms that may contribute to the rapid uncertainty increase for CH1 < 100. First, it is likely that some of the increased uncertainty in CH1 below values of 100 is inherent to sampling low concentrations, as is the case for any instrument. Second, the geometry of the laser sensing volume in the PMS can contribute to uncertainty in the CH1 at low concentrations, specifically if particles are not distributed uniformly within the laser beam.

(6a) Figure 10: the x-axis scale is unusual – please use linear or log-scale.

Figure 10 is now Figure 11 in the revised manuscript. The bin spacings on the original graph were just the SMPS size channels. The x-axis has been replaced by a logarithmic scale of MSD values where the upper and lower bin values are selected as $MSD_i+MSD_{i+1}/2$ and

MSD_i-$MSD_{i-1}/2$ where i refers to the i^{th} bin. The midpoints of the bins are 0.2239, 0.2512, 0.2818, 0.3162, 0.3548, 0.3981, 0.4467, 0.5012, 0.5623, 0.6310, 0.7079, and 0.7943. Although the MSD values were selected based on a log scale, they are plotted equally spaced from each other to maintain uniformity in the dimensions of the box and whisker symbols. The solid blue horizontal lines, which correspond to the number of observations in each bin, have been added for clarity.

We have added some more explanatory text, updated the figure to include points in each bin, and modified the caption to explain the unusual scale. This is the new text, figure, and figure caption:

The results are shown in Fig. 11 as a box and whisker plot of the $CH1avg/b_{sp1}$ values found in each MSD bin. The center MSD value for each bin is based on a logarithmic scale of MSD values where the upper and lower bin values are selected as $MSD_i+MSD_{i+1}/2$ and MSD_i-$MDS_{i-1}/2$ where i refers to the i^{th} bin. The thin black horizontal lines correspond to the number of observations in each bin and the scale is shown on the right hand axis. There are less than 20 values in the 0.22 µm, 0.63 µm, 0.71 µm, and 0.79 µm bins. Approximately 67% of the MSDs observed at BOS were between 0.29 µm and 0.36 µm, and 98% of MSDs were between 0.26 µm and 0.46 µm. The overall average $CH1avg/b_{sp1}$ ratio, based on 6777 observations, is 65 Mm.

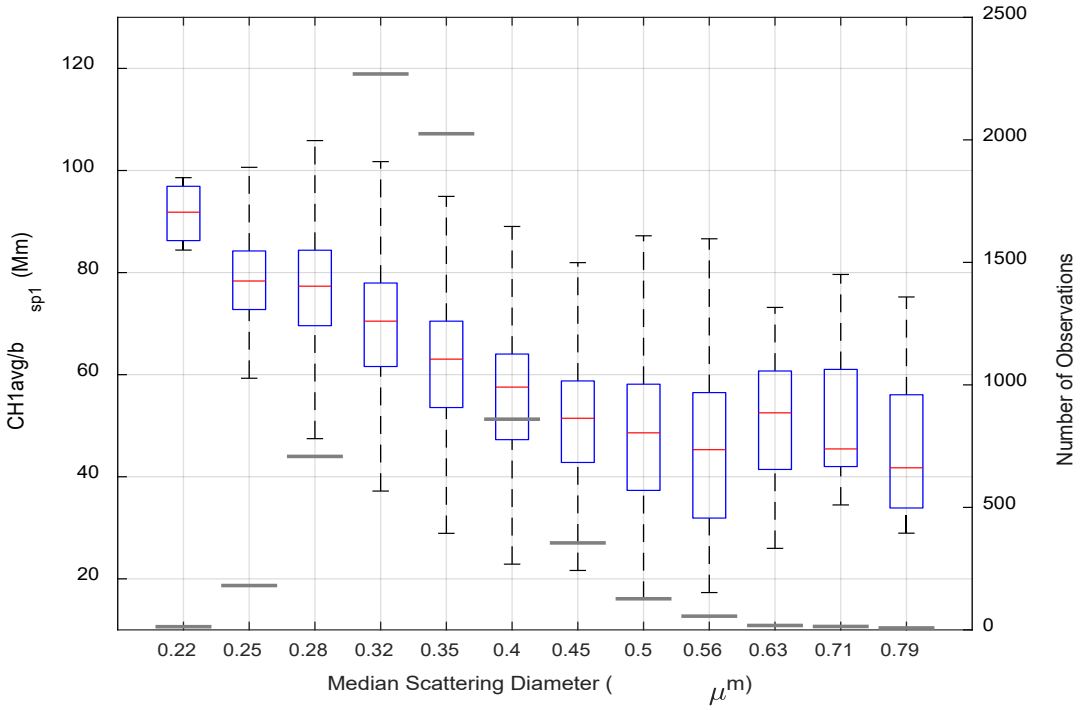

Figure 11. Observed decrease in $CH1avg/b_{sp1}$ ratio as a function of MSD values. MSD values were selected based on a log scale but plotted equally spaced from each other to maintain uniformity in the dimensions of the box and whisker symbol. Red line represents the median value, and the bottom and top of each box are the first and third quartile values. Extremes shown

on each box are the 2 and 98 percentiles. Black horizontal lines for each MSD value are the number of observations in the respective MSD bins.

(6b) Also, could these results be compared against model predictions as validation of model performance?

A comparison of modeled to measured PA response to the measured aerosol distribution is shown and discussed in Fig. 9.

(7) Section 4.5: It would be good to add a sentence or two about how the nephelometer was integrated with the DMPS for aerosol scattering coefficient distribution measurements.

We've expanded the sentence describing the scattering calculation from the DMPS as follows (new text is in red):

The 0.1 μm to 0.8 μm channels of the DMPS were used to calculate hourly-average fine aerosol scattering coefficient distributions and the total fine aerosol scattering coefficient, assuming spherical particles (Mie theory) with a refractive index of 1.53 - 0.017i.