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Atmospheric Measurement Techniques Discussions

Interactive comment on "The effect of rapid relative humidity changes on fast filter-based aerosol particle light absorption measurements: uncertainties and correction schemes" *by* Sebastian Düsing et al.

Anonymous Referee #1

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1 Review of Düsing et al., AMTD 2019

Düesing et al. have provided a systematic and detailed characterization of the bias of two widely-used commercial absorption photometers which results from exposure to step RH changes. While they have not solved the problems of these photometers, they have nevertheless provided useful quantitative data and useful correction schemes. The manuscript should be published in ACP after addressing all of my comments below. The most important comments are that the data must be weighted by

uncertainties before fitting, that the running mean the authors used has smoothed the data (and likely biased the fits), and that complete uncertainties must be provided for the authors' correction schemes.

2 Major comments

1. Section 2.1 (Theory of instruments) should be expanded to include mathematical statements of how the authors view the transient RH effects. In particular, it should be spelled out that M_{eBC} is based on the *difference* between subsequent attenuation measurements. This differential attenuation measurement also raises the possibility of investigating and correcting RH effects by looking directly at attenuation data. The authors should either look into this possibility, or discuss why they did not.

2. The use of a running mean for the MA200 means that the results are *not* equivalent to the 1-minute mean of the STAP. The running mean approach needs to be reconsidered. First, a running 60-second mean results in smoothing since each data point is used 3 times. Therefore the linear fits and R2 values reported are invalid since R2 is artificially enhanced by the autocorrelation which is inherent in a running mean. Best practice would be to analyze the 1-sec MA200 data *and* 60-sec mean MA200 data. The difference will provide insight into the STAP's limited time resolution. This point is related to my next point.

3. The changes in Figure 3 are rapid relative to the 1-minute averaging intervals used. This means that the signal cannot be accurately represented by a single value (mean) during periods of change (increasing/decreasing RH). I would predict that increasing/decreasing RH periods have systematically different biases in the residuals of Figure 4. To correctly account for these biases, uncertainties must be estimated and an orthogonal regression must be performed in Figure 4,

after weighting by these uncertainties. Most scientific software packages support this. Afterwards please highlight periods of increasing/decreasing RH in Figure 4 (eg with different symbols).

4. The authors have speculated extensively about the cause of the opposite trends of quartz and PTFE (lines 197-200). This speculation is of little value without experimental support. But I am not requesting experimental support. I am rather suggesting that the authors use these insights to design an improvement — use a mixture of the MA200 and TAP approaches to cancel out some of the biases of each approach. The utility of this suggestion can be tested by "simulating" a new instrument using the authors' measurements. The design details related to feasibility of this should be commented on.

5. In Figure 7, why did the authors not simply sample for a longer time with the MA200 in order to match the loadings on either instrument?

6. Line 260, not only the imaginary part of refractive index but also the real part will affect these results, since the real part will influence scattering (influencing attenuation as well as subsequent absorption). Please reword.

7. I would like to see the discussion clearly separate two RH effects for loaded filters: (i) impact of water uptake/adsorption by the filter on overall attenuation, (ii) impact of water uptake by the particles on the overall attenuation. Ideally (ii) would be observed by using a perfect filter material. Since none exists, this comment should be easily addressed with some changes to the text.

8. The correction schemes are not perfect, but they are useful. Certainly these and other authors will apply them at some point. It is therefore very important to report UNCERTAINTIES for the correction schemes. Both a percentage uncertainty and a bias (absolute value, in analogy to limit of detection) uncertainty must be reported.

The bias requirement is illustrated in Figure 10, where 2/Mm of false signal result from a step RH change of about 30%. This bias of 2/Mm means that a true signal of 1/Mm would hardly be measurable.

I do not know of a formal reference for handling this kind of bias, but I have encountered it in my own work and thought a bit about an easily understandable solution. My best suggestion is to allow users to answer the question: what is the minimum reported value which I can trust, if I am willing to accept a maximum inaccuracy of 25%? This question can be answered with a simple mathematical formulation which I will leave for the authors to provide. The answer to this question (the actual bias) will obviously depend on the magnitude of Δrh.

3 Minor comments

1. I would suggest taking the natural logarithm of Equations 1 and 2, or at least 2, so that the important terms (exponents of e) are more easily visible. Also, please at line 99 add a sentence clarifying that reinterpreting l as an aerosol path length does *not* mean that σ represents the aerosol absorption coefficient but still the filter attenuation coefficient.

2. Line 116, please change "provide" to "report" since the photometers only estimate eBC.

3. "Comparison" by who, are those unpublished results from the authors' lab?

4. Line 138 and 155, I suggest SI units of area.

5. Line 167, change "by passing" to "by passing it through" (this sentence required 3 reads to be understood)

6. I have not seen the term "floating mean" used before and an internet search did not bring up any definitions. I would recommend "running mean" (more precise, since floating implies complete freedom whereas running implies autocorrelation).

7. The Section "Recommendations" should be a numbered section or subsection, and no sections should come after Conclusions.

8. In Recommendations and the Introduction, the authors suggest avoiding fast changes by ascending slowly. This is simply not possible in some scenarios (unmixed layers, clouds) and this should be noted.

9. Table 1: I see no bold entries.

10. Table 2: Instead of custom formatting, add a column "Filter Number" which increases by 1 when appropriate.

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