Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2017-358-AC2, 2018

Atmospheric Measurement Techniques Discussions

Interactive comment on "A low-cost $PM_{2.5}$ monitor for wildland fire smoke" *by* Scott Kelleher et al.

Scott Kelleher et al.

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Received and published: 9 January 2018

We thank the reviewer for their insightful comments, which have allowed us to produce a stronger manuscript. Our responses to the general and specific comments are given below. Please note that line number references pertain to the "tracked changes" version of the revised manuscript.

Reviewer 2 general comments

This paper by Kelleher describes the design of a low-cost and field portable PM2.5 monitor that would be of interest to many readers, especially related to remote sampling without access to mains power. The authors give a thorough description of the design, components of their monitor that would enable one to replicate their monitor as well discussion on the consideration that went into the design. The authors demonstrated the use of the monitor in the field, describe the use to spatial mapping the distribution

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Discussion paper

of smoke from a prescribed burn in Colorado, and demonstrate that the monitor was able to successfully capture daily PM2.5 mass concentrations that compared well to reference instruments. The only downside to the paper is that I would have liked to have seen more discussion on the on-line optical sensor (Sharp) to monitor PM and the reasons why it failed. This will help the reader understand the limitations of the Sharp sensor and so avoid similar problems. In this reviewer opinion, the manuscript falls within the scope of AMT and should be considered for publication after consideration of the minor points below.

Please find our responses to the comments and clarifications detailed below, and details of the corresponding changes in the revised manuscript.

Reviewer 2 specific comments:

1. Comment: Page 4, line 95: Perhaps the authors could outline why they chose the Sharp optical sensor over the myriad of other lowcost particle sensors available commercially.

Response: lines 95-96 have been changed to outline why the Sharp was chosen over other low-cost sensors, “Wang’s evaluation of the Sharp demonstrated a linear response with aerosol concentration change and less dependency on atmospheric variables with respect to other low-cost sensors evaluated.”

2. Comment: Section 2.4: what sampling height did you place the monitors?

Response: The OAS samplers were placed at a height 1 meter off the ground to prevent sample contamination by ground dust and foliage.

We have revised line 153 of the text to read: “Each OAS was placed on a tripod at a height of 1 m and at a minimum of 60 m from the nearest road to avoid the influence of road dust emissions.”

3. Comment: Page 9, line 216: Perhaps you could compare the total battery life that was achieved during the measurements compared to the simulations?

Response: The ratio of energy collected by OAS during field deployment to the 24-hour average of solar irradiance striking the solar panels was 6.7 %. Solar irradiance reaching ground level can be absorbed or reflected by fire emissions overhead, reducing the flux of solar energy available for conversion by OAS solar cells. The 6.7% average efficiency was slightly less than the anticipated 7.5% efficiency used in the Monte Carlo model and design phase. Because aerosol loading effects were a primary determinant of reduced battery life (and because these effects were not modeled in the Monte Carlo simulation), it would be difficult to make a useful comparison of predicted vs. actual battery life.

4. Comment: Page 11, line 240: While I agree that you should correct for collection efficiency of the filter, it would help if the authors were a bit more explicit in how the correction was applied

Response: We apologize for the confusion; the specific methods for estimating filter collection efficiency and applying those corrections to reported data were described in detail in the manuscript appendices but not in the manuscript itself. We have added the following clarification to line 256: "The estimated mass collection efficiency of these filters was 66.7% (see supplemental material for a description of the method to evaluate filter collection efficiency), assuming a size distribution for an unaged biomass burning aerosol (Sakamoto et al., 2016). Mass concentration data reported here have been corrected for filter collection efficiency."

For your reference, we have uploaded the revised appendices with this response.

5. Comment: Page 11, line 245: why would the high mass loading reduce battery power, was it because the pumps had to work harder than expected?

Response: Yes, higher particulate loadings induce higher pressure drops across the filter meaning pumps work harder to maintain a specific flow rate through the filter. Please see our response to Reviewer 1, Comment 2 for more detail.

6. Comment: Figure 7: For each site on the maps you give an 'average' PM2.5 daily mass concentration. How is this an average concentration when each map is one day of measurements and there is presumably one OAS at each site?

Response: The numbers shown in Figure 7 represent 24-hr, time-weighted average concentrations (i.e., gravimetric PM2.5 mass) for a given OAS at each location. The numbers refer to time-averaged concentrations and the colors refer to interpolated values between monitor locations.

7. Comment: Figure 7 and S3: what happed to data from the 11th, 13th, 14th and 16th Sept? Why is data from these days not included in the Supplement?

Response: There was an 8-hour break between each sampling event because of the time required to complete the 102-mile round trip and service all of the samplers (replace filters, extract data, check flow rate, etc). Thus, we did not conduct sampling on all fire days. Fire operations were paused the 13th and 14th due to poor weather conditions and rain.

8. Comment: As mentioned previously, I think more discussion on the why the Sharp optical sensor failed would be useful. The authors mentioned baseline correction was attempted but give no details, what variables were tried but failed? Or to put it another way, how did you come to conclusion that the baseline was not correctable? As the strong linear trend with temperature suggested that it could be correctable. By giving details of what did not work is just as valuable for the reader, so that they can avoid similar issues with this sensor. Furthermore, have other people reported the same problems (e.g. Wang et al. 2015)?

Response: Besides a strong dependence on temperature, the Sharp sensors showed a baseline drift that was difficult to predict. We have created a supplementary Figure (S7) that depicts the various forms of baseline drift among four Sharp sensors that were co-located outdoors for seven consecutive days. These sensors were placed in a box (in the shade) with a common fan circulating air across the devices. The S7 time series

plot has been annotated to specifically highlight issues with sensor drift that rendered the Sharp sensor unreliable.

9. Comment: Figure 9: What about the results from the second location were the OAS was co-located with reference instruments, did it perform just as well?

Response: Results between OAS and reference monitor at location 9 were inconsistent and excluded from our analyses because we do not believe we could achieve an adequate comparison at this site. Two reasons contributed to this decision. First, at the request of the operator, the OAS was located approximately 10 m away from the reference monitor at this site. While a 10m separation distance would normally not be a big issue for a co-location study, the reference instrument was located just a few meters from a gravel road (i.e., a local PM source). This road experienced considerable vehicle traffic during the study (a 50-person camp associated with fire operations was located just meters away). Second, vehicles regularly passed by these locations, generating extremely high dust levels. Because the OAS and reference monitor were not located immediately adjacent to each other (our monitor was farther away from the road) we believe the comparison at this location is not valid.

10. Comment: Page 16, line 333: there have been a few recent papers that have found reliable low-cost and small optical particle counters (e.g. Crilley et al.2017 & Sousan et al. 2016). I think the authors could reference these and other papers here with discussion on whether these other sensors may be useful and practical.

Response: We agree and have added these references to the manuscript, line 380, where we discuss future work to incorporate improved optical sensors into the OAS.

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2017-358/amt-2017-358-AC2-supplement.pdf

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-358, 2017.