A low-cost monitor for simultaneous measurement of fine particulate matter and aerosol optical depth – Part 3: Automation and design improvements

The authors present improvements in AMOD sensing device for concurrent PM2.5 and AOD measurements. They describe a sample deployment of 10 AMODv2s for 2.5 days during a wildfire smoke event, and they present a 7-day validation campaign of the AMODv2 that was co-located with a AOD reference device. The results indicate close agreement between AMODv2s and the reference instrument although they identified some intra-device variability. They conclude that the AMODv2 is well suited for citizen science and other high-spatial-density deployments due to its low cost, compact form, user-friendly interface, and high measurement frequency of AOD and PM2.5.

The paper addresses an important topic, a cost-effective strategy for improving satellite estimates of PM2.5 concentration. They present results to support their statements about measurement accuracy. However, it presents rather limited data to support many of the authors' other conclusions. The paper would be strengthened with additional data. It also requires some clarification regarding real-time presentation of PM2.5 concentrations as well as some date inconsistencies. If additional results are not possible, the manuscript may be more suitable as a technical note.

Significant weaknesses

Limited scope of data. The website presented in the paper illustrates that the AMODv2s are collecting and presenting measurements to the public, which is great. It is puzzling why the authors present only 2.5 days of measurements (2 days of AOD measurements) from 14 devices. This limited data set also makes it difficult to support the authors statements that the system is autonomous. The paper would be greatly strengthened if they:

- Presented longer-term measurements, which is one of the key motivations for this developing autonomous measurements
- Co-located a few AMODv2s to understand intra-device variability, and have long-term validation measurements by co-locating the AMODv2s with AOD reference devices for a long time period (seasons to a year). The manuscript provides some evidence that device to device variability could be important.
- Presented data that indicates the autonomous nature of the device, % of device up time, and number of valid AOD measurements (quality control described with triplicate measurements), number of AOD measurements excluded for cloud cover, etc. This needs to be done for weeks or months of measurements to begin to support the autonomous claims in the manuscript.

The validation measurements of AMODv2 are also limited. The authors state that their validation measurements cover a range of conditions, which is important. If the AMODv2 is capable of autonomous measurement, it is unclear why the validation results are so limited. It is also unclear how the authors came to 426 data paired points. I would encourage them to include a table in the supplementary materials that presents the device ID, the number of valid AOD measurements each day, the number and % of excluded measurements (if any), % of missing data and the cloud and PM2.5 conditions of the day. I struggled with understanding how 426

paired data points were achieved. If the sampling rate was 2.5 to 3 minutes, are they presenting the results of each test (one every two to three hours, this would get closer to 426 data points were the samples averaged?) or samples selectively included.

With less than 10 days of data total (2.5 of sample deployment and 7 days of validation), it is difficult to see how this annual calibration recommendation is reached. Line 408: "To mitigate unit specific errors, we recommend re-calibrating instruments at least one time per year."

PM2.5 concentrations. The paper presents PM2.5 measurements from the Plantower PMS5003. The authors need to clarify if they are presenting measurements that were corrected with their on-board filter measurements (or if these are raw measurements or corrected using some other strategy). They should provide these filter-based correction factors in the supplementary material. If they are using some other method, they should describe this. They should also describe if they are applying corrections to Plantower's raw ATM or CF=1 measurements.

Also, in several places in the manuscript, the authors discuss real-time visualization and data access. However, as the authors and others have published previously the Plantower PMS 5003 raw measurements are biased. They require a correction factor for the aerosol conditions of interest. Reasonably accurate real-time PM2.5 concentration estimates would not be possible if the filter cartridges require one week of sampling, must be mailed in, and weighed. These corrections would only be possible weeks after the PM2.5 measurements are posted. The authors need to clarify what they are presenting and if the measurements are corrected how they are corrected.

Moderate weaknesses

Table 1. What types of conditions are being presented here. All 7 days or a subset? How do the statistics vary by condition?

The manuscript in places reads a little like an advertisement for the AMODv2. The authors should focus on statements that are supported by their results (i.e., the terms autonomous, real-time, user friendly, use for citizen science). See comments about autonomous and real-time in the previous section.

Figure S7 does not occur during either the sample deployment (October 2021 or maybe 2020, see comment on date inconsistencies below) or during the co-location validation testing. It is unclear why the authors would select a time other than the sample deployment described in the paper. If there is a good reason, they should provide it. They should also discuss the causes of the PM2.5 concentration peaks. Also, this figure illustrates that more than one half of the AMODv2s are offline (see comment about autonomous).

Given that the AMODv2 requires WiFi, wouldn't it be reasonable to have a plug in option, which would likely increase up-time, see comment regarding figure S7.

It is unclear why the authors present only 2.5 days of results when the devices are capable of 5 days of measurements.

This may be just my eyes, but Figure 4 doesn't look like it contains 426 data points.

The Figure 2 shows one sampling interval rather than continuous sampling. The filter cartridge needs to be replaced and the instrument restarted. This should be included in the figure.

Line 288 The authors discuss their sample deployment of co-located 10 AMOD units during a wildfire smoke event in Fort Collins, Colorado in October of 2021. I believe that they mean October 2020 since October 2021 has not yet occurred.

Line 374 The authors should clarify how they derived their expected error equations.

Line 427. The authors are not comparing apples to apples here. First, they are comparing their component costs to commercial instruments, which are likely 5 to 10X the component costs. Further the GRIMM EDM is a Federal Reference Method. A more reasonable comparison would be a low-cost particulate matter sensor, i.e., Purple Air at $250 or something like the TSI DustTrak $5000 with a cyclone cut point and filters that can be weighed.

Minor
Line 395 "by wavelength" is repeated