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Atmospheric Measurement Techniques Discussions
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Interactive comment on "Using Low Cost Sensors to Measure Ambient Particulate Matter Concentrations and On-Road Emissions Factors" *by* K. K. Johnson et al.

Anonymous Referee #1

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A much more technically rigorous assessment and thorough discussion of the limits of detection of the Shinyei low-cost PM sensors as pertains to the specific micro-environments to which they were deployed is necessary. Understanding sensor response to the bulk physio-chemical properties of the ambient PM distributions is fundamentally important and the rich 1-min data sets acquired by the authors hold some promise toward better informing the utility of these type of low-cost, IR, OPCs. The authors analyze and present a limited subset of a sparse, disparate experimental matrix. Laboratory-based, systematically-controlled calibrations for each of the low-cost PM sensors used here is a critically important pre-requisite to generating robust data handling protocols. Such laboratory assessments serve as the starting point for gen-

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Discussion paper

erating realistic error bars (exploiting best-case model PM scenario, minimum degrees of freedom in the experimental system). Such assessments must be completed prior to field deployment of low-cost sensors and subsequent interpretation of their data output. Through careful exploration of model PM distributions in the laboratory, the authors could begin to dis-entangle the complicating effects of particle size, refractive index, sensor-specific response (manufacturer or factory reproducibility (or lack thereof – changes in optical alignment), background levels (particle-free), and overall stability of sensor response over time in a constant PM concentration condition. The historical record of PM studies utilizing state-of-the-art characterization methods provides a template for what to expect in terms of the physio-chemical properties of near-roadside PM distributions, as well as developed and developing world urban background PM characteristics. Given this atmospheric intuition, the principle challenge in reconciling outputs from low-cost IR-based OPCs is the size detection limit of the device. If a given low-cost sensor can effectively measure 5% of the suspended 500 nm particles in a parcel of air, what mass fraction of the total PM2.5 is the device is able to detect? If the size distribution of the ambient PM is not static (i.e. dynamically changing from smaller to larger particles over the course of the day) what impact will that have on the PM2.5 mass fraction detected by the sensors? An underlying assumption in the correlation-approach utilized here is that the mass fraction of PM2.5 that the low-cost OPC is NOT detecting, remains constant. Based on the low R2 values reported in the manuscript and the microphysical processes governing PM emission and formation in the atmosphere, this missing mass fraction is most certainly not static. Interestingly, with larger size cut-offs for detection (1 um), the variability in the missing mass fraction may in fact decrease (especially in clean environments), improving correlations with co-located FRM and FEM. As written, the manuscript does not discuss their observations of low-cost OPC outputs in the context of the atmospheric PM2.5 distributions for each environment. The manuscript offers some important glimpses into the challenge of pollutant characterization with low-cost OPCs, but these insights do not comprise the bulk of the text or discussion.

I am in agreement with the comments of Anonymous Referees #3, #4, on all counts.

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