ALTERNATIVE METRICS FOR SPATIALLY AND TEMPORARILY RESOLVED AMBIENT PARTICLE MONITORING

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I. Introduction

One approach to monitor ambient PM concentrations is by using a mobile platforms to get temporally and spatially resolved information. Many different researchers had reported particle concentrations and distributions using particle sizing instruments such as Scanning Mobility Particle Sizer (SMPS, TSI Inc.) carried by a mobile platform (Fruin et al., 2008; Massoli et al., 2012; Pirjola et al., 2012). They provided detailed size distribution information, which is useful for research. However, particle size distribution measurement is not appropriate for a routine monitoring over a wide region. It is much more costly than other types of measurements for data collection and analysis. It is also difficult to present PSDs to show spatiotemporal evolution and distribution.

Therefore, a single valued metric such as particle concentration and/or particle surface area are ideal to understand temporal and spatial variations of particle emissions on and near road. However, single metrics themselves do not provide information on particle transport. This study aims to show the ratio of particle surface area and concentration contain information related to particle size distribution. Thus, it is suggested to monitor two metrics (PN and PS) to obtain three information (PN,PS and GMD).

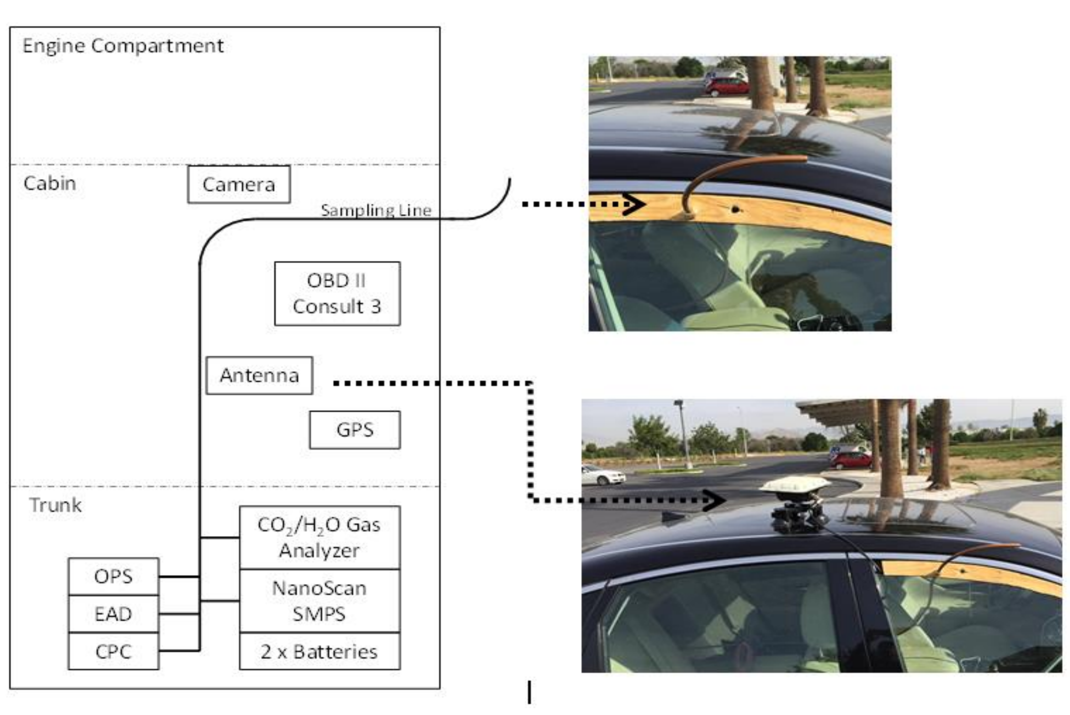
This study used CPC and EAD as monitoring instruments. Nanoscan SMPS was used to as a means to confirm the measurement by CPC and EAD to prove the concept and it is not recommended to be included in the routine monitoring.

II. Methods

Mobile Platform Measurement Instruments:

- Infinity M37 gasoline vehicle
- Condensation particle counter
- Electrical aerosol detector (TSI EAD 3070A)
- Portable scanning mobility particle sizer (TSI NanoScan SMPS 3910)
- Trimble R8 GPS
- Instruments powered by a deep cycle marine battery (U.S.Battery, model US 2200 XC2)

Schematic diagram of instrument installation at a mobile platform.



Driving Route on SR-91

The vehicle was consistently on the second most left lane (next to the HOV lane) of the highway except when exiting the highway.

III. Results

EAD response in mm/cm³ can be calculated from SMPS size distribution data using Equation 1

$$EAD\ response[mm/cm^3] = 5.146\cdot 10^{-4}\sum_i n_i d_i^{1.13} \qquad \text{Equation 1}$$

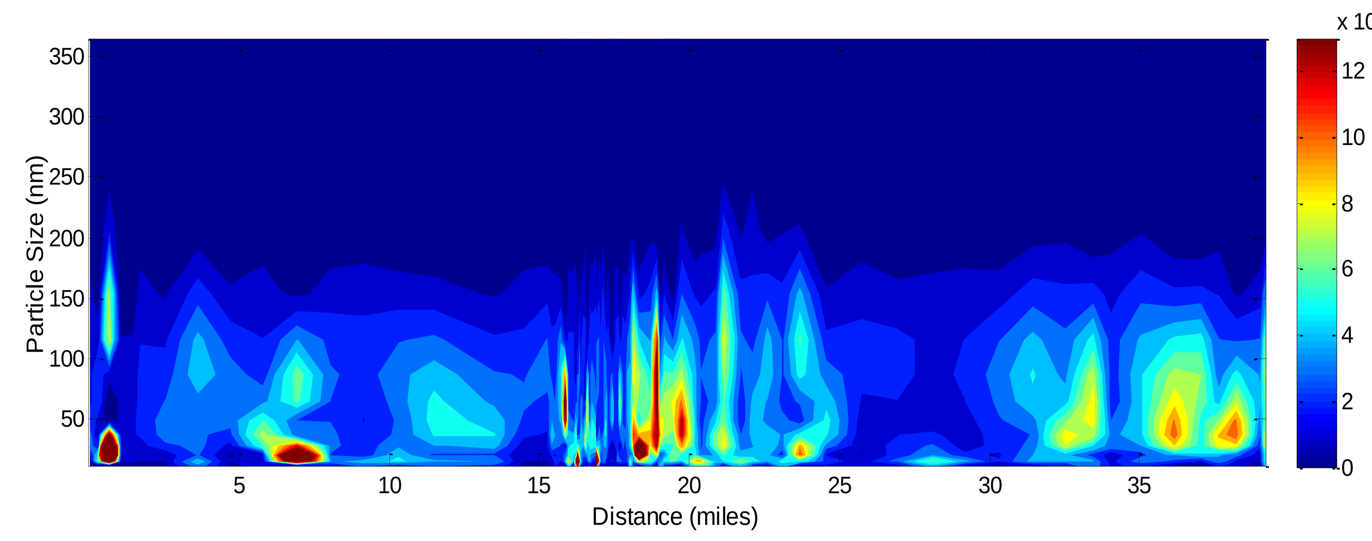
The diameter of average active aerosol surface area for a given particle size distribution can be obtained as a function of EAD/CPC ratio

$$d_{\overline{1.13}} = \left(\frac{1}{c}\right)^{\frac{1}{1.13}} \cdot \left(\frac{EAD\ response}{CPC\ response}\right)^{\frac{1}{1.13}} \qquad \text{Equation 2}$$

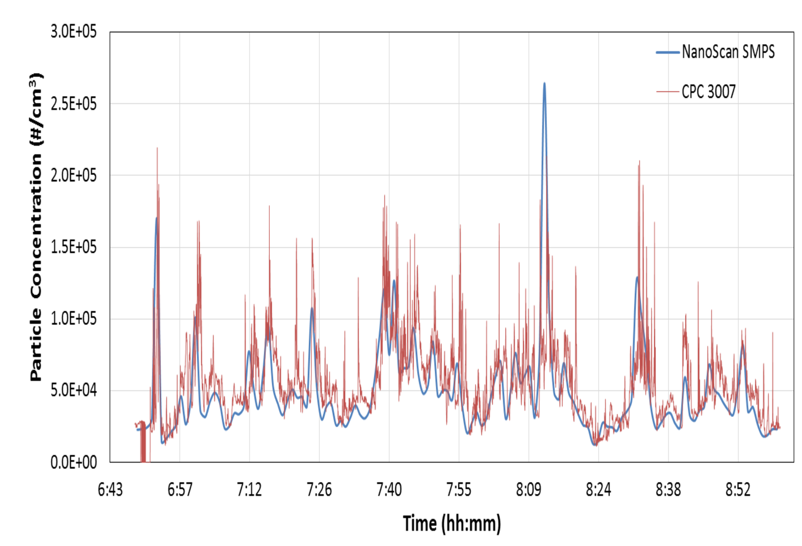
The GMD of the equivalent lognormal PSD can be determined as a function of EAD/CPC ratio once the geometric standard deviation of the lognormal distribution is known.

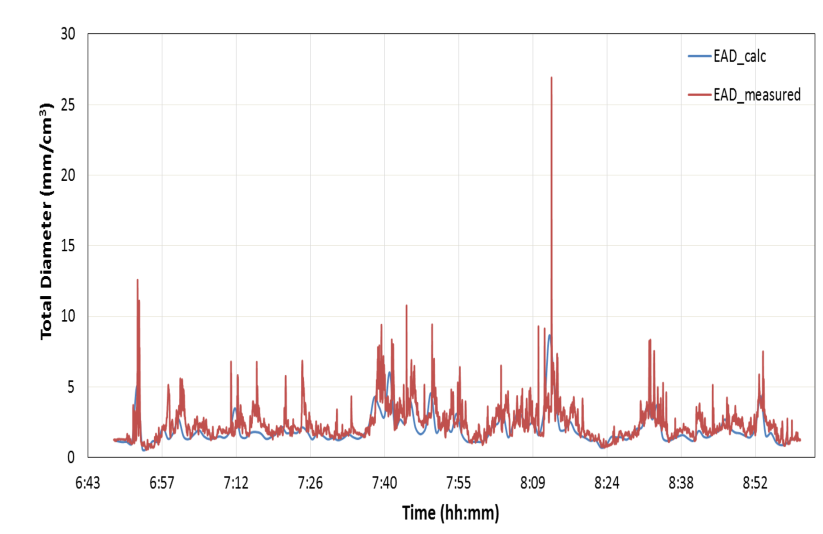
$$GMD = \frac{\left(\frac{1}{c}\right)^{1.13}}{\exp\left[\frac{1.13}{2}\ln^2\sigma_g\right]} \cdot \left(\frac{EAD\ response}{CPC\ response}\right)^{\frac{1}{1.13}} \qquad \text{Equation 3}$$

The NanoScan SMPS measured a particle size distribution every minute while the mobile platform was moving in the route. The particle size spectra showed dynamic changes of particle size distributions due to traffic. Particle size distributions measured by the NanoScan SMPS were used to check consistency of the EAD, CPC measurement, and EAD/CPC ratio.

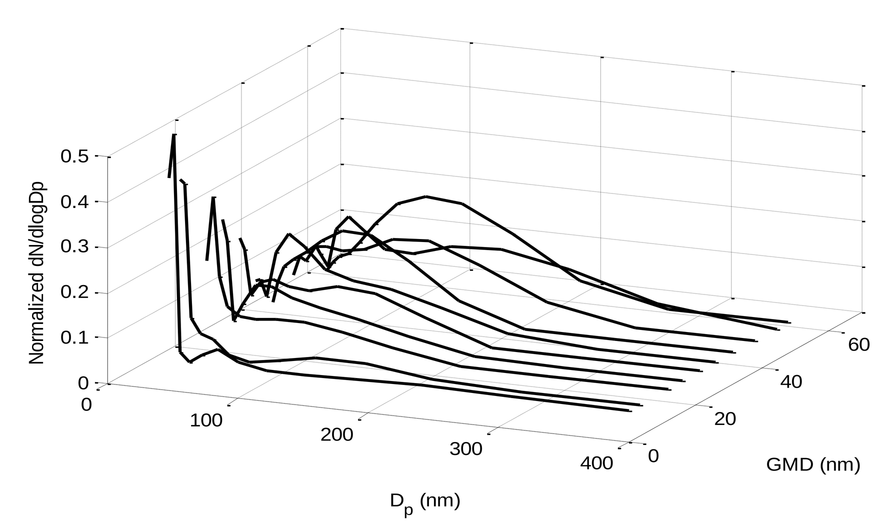


Total particle size distribution and active particle surface area which was integrated and converted from the particle size distributions of NanoScan SMPS were compared with CPC and EAD measurement.



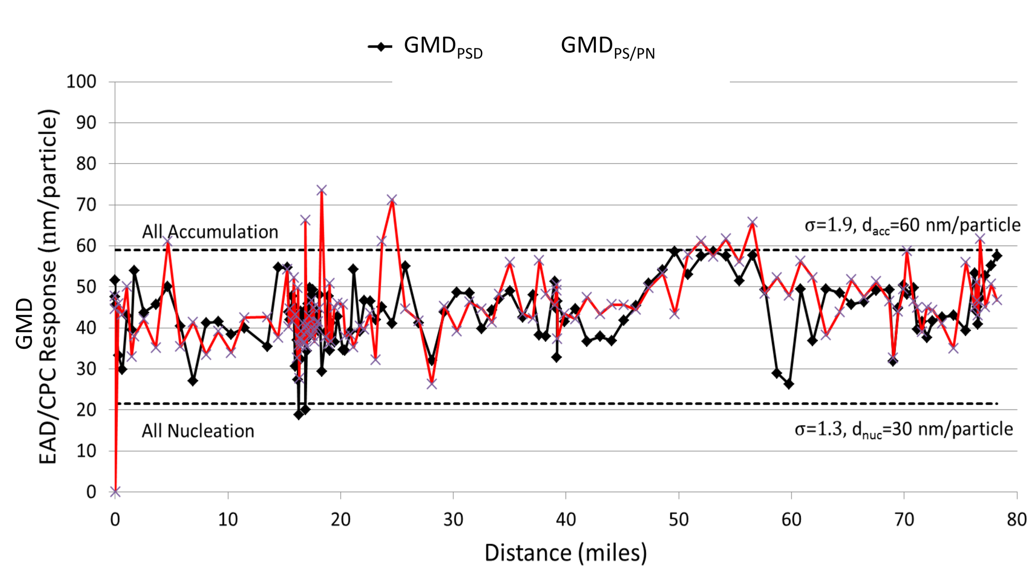


To further understand the physical meaning contained in EAD/CPC ratio, several particle size distributions from the route was sampled in the order of EAD/CPC ratio. The EAD/CPC ratio was chosen to have a constant increment of ~5 nm in terms of GMD that was calculated from the size distribution. The particle count in each bin was normalized by the total count of the size distribution. As the ratio EAD/CPC increased, the profile showed a transition from nucleation to accumulation mode.



GMDs of nucleation mode ranged from 3 to 40 nm with an average GMD of 17 nm. GMDs of accumulation mode ranged from 27 to 155 nm with an average GMD of 56 nm. Average GSDs were 1.4 and 1.7 for nucleation and accumulation mode, respectively.

Comparison of GMDs between from the measurement of EAD and CPC (for $GMD_{PS/PN}$) and measurement of particle size distribution (for GMD_{PSD}).



IV. Conclusion

- The EAD and CPC response calculated and integrated from the SMPS data correlated well with the measured EAD and CPC response.
- The ratios of PS and PN (or EAD/CPC) was used to calculate the GMD of a lognormal PSD which has an equivalent total particle surface area.
- The GMDs calculated from SMPS data and EAD/CPC ratio measurement agreed well and they provide size information which is important to understand particle transport.

V. Acknowledgement

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VI. References

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