Particle Density and Shape Factors Estimated from Merging Aerodynamic and Mobility Distributions

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Introduction

- Different instruments provide different measures of aerosol size:
  - aerodynamic (cascade impactors, APS)
  - mobility-equivalent (SMPS)
  - vacuum-aerodynamic (Aerodyne AMS)
- Combining measurements from these instruments into a single spectrum provides an insight into other aerosol characteristics, such as particle shape and density.

Approach

- Measurements were carried out at the central site of the Pittsburgh Air Quality Study.
- A simple algorithm was developed to combine electrical mobility and aerodynamic size distribution data into a single size distribution by finding best-fit shift of the APS distribution to match SMPS in the overlap range.
- The integrated aerosol volume from merged size distribution was compared to the $PM_{2.5}$ mass concentration measurements using TEOM, providing a measure of the average bulk aerosol density.
- SMPS size distributions were compared to the distributions measured with Aerodyne Aerosol Mass Spectrometer (AMS) using density estimated from concentrations of aerosol components measured with the AMS.
- The aerosol density was estimated from a comparison of SMPS-APS volume with $PM_{2.5}$ mass measured with TEOM. Data on chemical composition measured with AMS was also used to estimate aerosol density.

Results

- Merging algorithm for combining SMPS and AMS distributions provides a better comparison with integrated instruments such as TEOM (Fig. 1, 2).
- Merged distributions show a good agreement with MOUDI cascade impactor measurements (Fig. 3).
- The slope of TEOM mass vs. SMPS-APS volume provides a measure of particle density (during the study ambient particles were wet, having shape factor of 1).
- Estimated "apparent" aerosol density from TEOM / SMPS-APS comparison is on average 1.5 g/cm^3 ±20%. The estimated density is in good agreement with the density estimated from chemical composition data (1.56 g/cm^3).
- Comparison of AMS mass concentrations and SMPS volume concentration provides an estimation for the density of particles of 1.5 g/cm^3, which is close to the estimation using chemical composition measured with AMS. However, there are occasional *apparent* discrepancies between the instruments likely due to the presence of highly non-spherical soot particles during rush hour periods, as has been observed at other urban sites (Fig. 4).

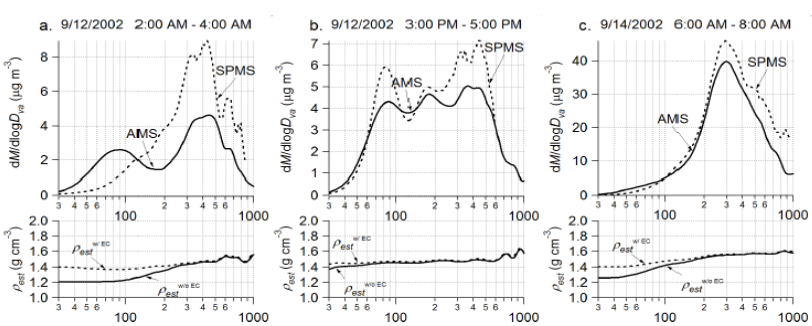

Fig.4. Comparison of mass size distributions measured with SMPS and Aerodyne AMS.

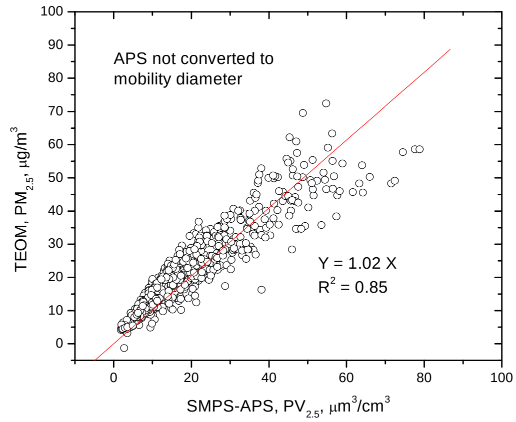

Fig.1. Comparison of aerosol volume measured with SMPS-APS (without conversion) and $PM_{2.5}$ mass measured with TEOM.

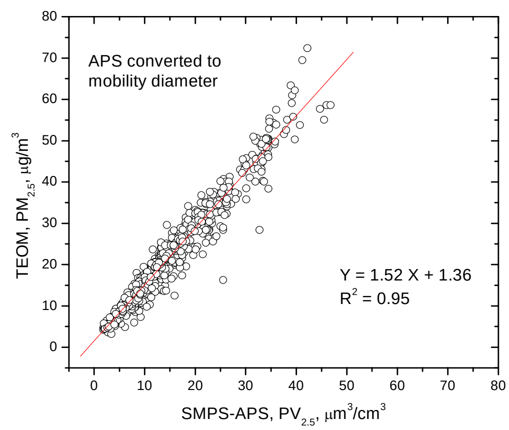

Fig.2. Comparison of aerosol volume measured with SMPS-APS (with conversion) and $PM_{2.5}$ mass measured with TEOM.

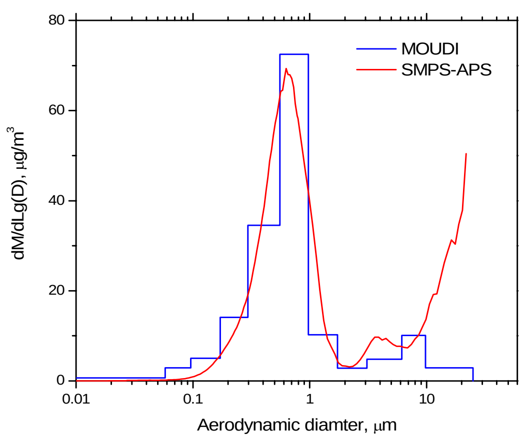

Fig.3. Comparison of mass size distributions measured with merged SMPS-APS (density 1.5 g/cm^3) and MOUDI cascade impactor.

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