Analysis of Aerosol Particle Number Size Distributions in Beijing and Guangzhou, China

Jie Wang, Jianguo Liu, Huaqiao Gui, Nanjing Zhao
Anhui Institute of Optics and Fine Mechanics, China Academy of Sciences

May 12, 2010
Contents

• Introduction
• Methodology
• Results and Discussion
• Conclusion
Introduction
Methodology

Aerodynamic Size

- Electrical Low Pressure Impactor, ELPI
- Micro-orifice Uniform-Drop Impactor, MOUDI
- Nano-MOUDI

Optical Scatter Size

- Laser Particle Spectrometer, LPS

Diffusion Size

- Electrical Aerosol Analyzer, EAA
- Differential Mobility Analyzer, DMA
- Scan Mobility Particle Spectrometry, SMPS
- Nano-SMPS

Multi-grade SMPS+FCE (Faraday Cup Electrometer)

Size Range (nm)

1
10
100
1000
10000

Electrical Mobility Size (Stokes Size)

Aerodynamic Particle Spectrometer, APS
Methodology - Fine Particle Meter (FPM)

FPM

- **SMPS+C**: 5nm~500nm
- **LPS**: 350nm~10μm

Wide-range measurement from 5nm to 10μm
Methodology - Aerosol Particle Diameter Spectrometer (APDS)

**APDS:** 500nm~10μm
Location of sampling sites
Characteristics of particle number size distribution before and during Olympic Games in Beijing

Average value of particle number concentration in every mode in different weather conditions

<table>
<thead>
<tr>
<th>Measuring time</th>
<th>Nucleation mode (cm$^3$)</th>
<th>Atiken mode (cm$^3$)</th>
<th>Accumulation mode (cm$^3$)</th>
<th>Total (cm$^3$)</th>
<th>PM10 (μg·m$^{-3}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20080720-0807</td>
<td>350</td>
<td>3100</td>
<td>2570</td>
<td>6050</td>
<td>162</td>
</tr>
<tr>
<td>20080808-0824</td>
<td>500</td>
<td>3800</td>
<td>1500</td>
<td>5800</td>
<td>78</td>
</tr>
</tbody>
</table>

- Key Lab. Of Environmental Optics & Technology, CAS
Characteristics of particle number size distribution in typical weather conditions

Typical weather conditions

- **Rainy (20080810~0811)**
  - Temperature: 26.5°C
  - Humidity: 88.8%
  - Visibility: 6.8km

- **Haze (20080813)**
  - Temperature: 29.8°C
  - Humidity: 72.4%
  - Visibility: 3.7km

- **Sunny (20080815)**
  - Temperature: 28.6°C
  - Humidity: 59.3%
  - Visibility: 41.8km
Characteristics of particle number size distribution in typical weather conditions

- **Rainy Day (a)**
  - Particle diameter (nm)
  - Number concentration (cm⁻³)

- **Haze Day (b)**
  - Particle diameter (nm)
  - Number concentration (cm⁻³)

- **Sunny Day (c)**
  - Particle diameter (nm)
  - Number concentration (cm⁻³)

**Graphs and Data**

- **Dotted Lines**
  - Drift correction mode
  - Aitken mode
  - Accumulation mode
  - Total concentration

**Time Periods**

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Day</th>
<th>Start Time</th>
<th>End Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>8</td>
<td>1</td>
<td>00:00</td>
<td>12:00</td>
</tr>
<tr>
<td>2008</td>
<td>8</td>
<td>1</td>
<td>12:00</td>
<td>24:00</td>
</tr>
<tr>
<td>2008</td>
<td>8</td>
<td>1</td>
<td>24:00</td>
<td>00:00</td>
</tr>
</tbody>
</table>

**Concentrations**

- Drift correction mode: 1000, 7007, 4910, 3441, 2411, 1699, 1184, 629.5, 581.3, 407.3, 285.4, 250.0
- Aitken mode: 3441, 4910, 7007, 10000
- Accumulation mode: 1000, 10000
- Total concentration: 1000, 10000

**Legend**

- Drift correction mode
- Aitken mode
- Accumulation mode
- Total concentration

**Key Lab. Of Environmental Optics & Technology, CAS**
The visibility during 2008 Beijing Olympic Games
The location of sampling site
Particle number size distribution and concentration of Beijing and Guangzhou

The temperature and relative humidity of Beijing and Guangzhou during the experiment periods

<table>
<thead>
<tr>
<th>Experiment period</th>
<th>Diurnal average temperature</th>
<th>Diurnal average relative humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>Beijing Jul. 20~Aug. 24</td>
<td>23.0°C</td>
<td>30.4°C</td>
</tr>
<tr>
<td>Guangzhou Oct. 10~Nov. 20</td>
<td>21.0°C</td>
<td>28.4°C</td>
</tr>
</tbody>
</table>

(a) 
(b) 
(c) 
(d)
Particle number size distribution of sunny and haze days in Guangzhou

Average value of meteorological parameters in different weather conditions in Guangzhou

<table>
<thead>
<tr>
<th></th>
<th>Temperature</th>
<th>Humidity</th>
<th>Visibility</th>
<th>Nucleation mode</th>
<th>Atiken mode</th>
<th>Accumulation mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunny day (20081019)</td>
<td>28.0°C</td>
<td>63%</td>
<td>12.0km</td>
<td>2400</td>
<td>8300</td>
<td>1800</td>
</tr>
<tr>
<td>Haze day (20081023)</td>
<td>28.0°C</td>
<td>68%</td>
<td>5.0km</td>
<td>1800</td>
<td>7600</td>
<td>2400</td>
</tr>
</tbody>
</table>

Key Lab. Of Environmental Optics & Technology, CAS
Comparison of particle number size distribution in haze day of Beijing and Guangzhou

Average value of meteorological parameters in haze days

<table>
<thead>
<tr>
<th>Observation site</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing(20080813)</td>
<td>29.8°C</td>
<td>72.4%</td>
<td>3.7km</td>
</tr>
<tr>
<td>Guangzhou(20081023)</td>
<td>28.0°C</td>
<td>68%</td>
<td>5.0km</td>
</tr>
</tbody>
</table>
Comparison of PNSD in haze day between Beijing and Guangzhou

Average value of particle number concentration in every mode in haze days

<table>
<thead>
<tr>
<th>Observation site</th>
<th>Nucleation mode (cm⁻³)</th>
<th>Atiken mode (cm⁻³)</th>
<th>Accumulation mode (cm⁻³)</th>
<th>Total (cm⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing(20080813)</td>
<td>300</td>
<td>3300</td>
<td>1900</td>
<td>5500</td>
</tr>
<tr>
<td>Guangzhou(20081023)</td>
<td>1800</td>
<td>7600</td>
<td>2400</td>
<td>11800</td>
</tr>
</tbody>
</table>
Particle number size distribution of in sunny day between Beijing and Guangzhou

<table>
<thead>
<tr>
<th>Sampling site</th>
<th>Temperature</th>
<th>Humidity</th>
<th>Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing(20080815)</td>
<td>28.6°C</td>
<td>59.3%</td>
<td>41.8km</td>
</tr>
<tr>
<td>Guangzhou(20081019)</td>
<td>28.0°C</td>
<td>63%</td>
<td>12.0km</td>
</tr>
</tbody>
</table>
Particle number size distribution of sunny day of Beijing and Guangzhou

<table>
<thead>
<tr>
<th>Observation site</th>
<th>Nucleation mode (cm⁻³)</th>
<th>Atiken mode (cm⁻³)</th>
<th>Accumulation mode (cm⁻³)</th>
<th>Total (cm⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing(20080815)</td>
<td>1100</td>
<td>4800</td>
<td>700</td>
<td>6600</td>
</tr>
<tr>
<td>Guangzhou(20081019)</td>
<td>2400</td>
<td>8300</td>
<td>1800</td>
<td>12500</td>
</tr>
</tbody>
</table>
The location of Hefei sampling site
Particle number size distribution and concentration of Hefei

### Particle number concentration in each mode (cm$^{-3}$)

<table>
<thead>
<tr>
<th>City</th>
<th>Beijing</th>
<th>Hefei</th>
<th>Guangzhou</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleation mode</td>
<td>439</td>
<td>575</td>
<td>2559</td>
</tr>
<tr>
<td>Aitken mode</td>
<td>3461</td>
<td>2894</td>
<td>7613</td>
</tr>
<tr>
<td>Accumulation mode</td>
<td>2051</td>
<td>1945</td>
<td>1920</td>
</tr>
<tr>
<td>Total</td>
<td>5951</td>
<td>5414</td>
<td>12092</td>
</tr>
</tbody>
</table>
Conclusions

※ By using Fine particle meter (FPM-1), experiments of particle number size distributions have been successfully held in Beijing, Guangzhou and Hefei from the year 2008 to 2010.

※ The curve of particle number size distribution of Beijing are similar to that of Hefei, such as the peak diameter and concentration, but quite different from that of Guangzhou.

※ It is obviously that the number concentrations of nucleation mode and aitken mode particles with diameters below 100nm of Beijing is much lower that Guangzhou, and the concentration of accumulation mode particles with diameter 100~1000 nm only show a little differences on magnitude.

※ The visibility is deeply influenced by the rain. Quantity analysis have shown that the visibility of Beijing during Olympic Game was strong effected by the number concentration of particles with diameter above 500nm.

※ The curve of particle number size distribution of Hefei is obviously in two-peak pattern, and the value of dustfall aerosol shows that concentration of particle with diameter between 400nm~10µm is much high than other periods.
Thanks for your attention!