Preliminary Analyses of PM2.5 ACSM Measurements in Handan, China

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Presented by Ping Chen on Oct. 22 at the 2016 AMS User’s Meeting in Portland, Oregon, USA
For many years Aerodyne had been developing a PM2.5 aerodynamic particle sampling lens (Xu et al., 2016) and a particle capture vaporizer (Hu et al., 2016).

By the spring of 2015, the PM2.5 lens and capture vaporizer had already gone through extensive lab tests.

In May 2015, a Q-ACSM with a prototype PM2.5 lens and a prototype capture vaporizer was ordered by Handix, with the intention to deploy the system in China and test its vitality in routine monitoring in more polluted environment.

In June 2016, the PM2.5 ACSM was delivered to Handix (Nanjing, China).

Since then, the PM2.5 ACSM has been deployed in Nanjing (July – October, 2015), Handan (Dec. 2015 – Feb. 2016), and Guangzhou (Oct. 2016 - present). Starting in Nov. 2016, the unit will be deployed in Beijing.

This morning, Phil showed some results for the experiment in Nanjing. In the following, I will show some preliminary results from the deployment in Handan city.
Why in Handan?

- Handan city, with a population of about 2 million, is located about 400 km southwest of Beijing.

- It is often on the top-10 list of most polluted cities in China.

- Most pollutants are from coal combustions in the steel and chemical plants, vehicle emissions, and civilian heating, etc.
Sampling site

- The sampling site is on the rooftop of a 5-story building on the campus of Hebei University Of Engineering.

- It is near the edge of the city and about 450m away from a main highway.
Instruments and Collaborators

1. PM2.5-ACSM (Handix/Aerodyne)
2. Xact-625 (Handix/CES)
3. PM1.0-ACSM (Tsinghua University)
4. PAX (Tsinghua University)
5. SMPS (Tsinghua University)
6. MAAP (Tsinghua University)
7. BAM (Beta Attenuation Monitor) for PM1 mass loading (Academy of Environmental Sciences of Hebei Province)
8. PTR-MS (Academy of Environmental Sciences of Hebei Province)
9. ECOTECH Nephelometer (Academy of Environmental Sciences of Hebei Province)
10. TEOM (Tapered Element Oscillating Microbalance) for PM2.5 mass loading (Hebei University Of Engineering)
11. Personal Weather Station (Hebei University Of Engineering)
12. POPS (Handix)
13. APS (Tsinghua University)
Experiment Timeline

Dec. 4, 2015
Personal Wether Station,
ACSM (PM1.0, PM2.5)
TEOM PM2.5
PAX, SMPS, M
AAPDec.
BAM PM1.0, PTR-MS, ECOTECH NEPH

Dec. 4, 2015
APS, POPS

Jan. 19, 2016
10:16 FCB flow rate for ACSMs increased from 2LPM to 3LPM.

Jan. 20, 2016
Xact-625

Feb. 29, 2016
Sampling flow rate was changed to 3LPM
• Flow rate set to 2LPM;
Compositions Pie Chart

- **Total Mass:** 277.57 µg/m³
- **Org:** 47.8%
- **NH₄:** 7.8%
- **SO₄:** 6.8%
- **NO₃:** 6.4%
- **Chl:** 20.6%
- **BC:** 10.6%
Mass loading: PM2.5-ACSM vs TEOM(PM2.5)

Coeficient values ± one standard deviation:

- \(a = 24.810 \pm 4.142\)
- \(b = 1.016 \pm 0.014\)
- \(r^2 = 0.843\)

--- Line: 1:1
Mass loading: PM2.5-ACSM vs BAM(PM1.0)

Coefficient values ± one standard deviation:
- \( a = 13.621 \pm 5.660 \)
- \( b = 1.035 \pm 0.040 \)
- \( r^2 = 0.817 \)

--- Line 1:1
Mass loading: (ACSM + PAX) vs TEOM (PM2.5)
Mass loading: (ACSM + PAX) vs BAM(PM1.0)

Coefficient values ± one standard deviation:

- $a = 11.214 \pm 5.547$
- $b = 1.153 \pm 0.039$
- $r^2 = 0.852$

--- Line 1:1
• After the flow rate was changed from 2 LPM to 3LPM on Jan. 16, 2016 10:16am;
Peak at 9:00

Difference:
dust cannot be vaporized by VapT=600°C, nor detected by PAX or Xact.
Without outliers:
Coefficient values ± one standard deviation
\[ a = 9.88 \pm 1.67 \]
\[ b = 0.76 \pm 0.0128 \]
\[ r^2 = 0.789; \]
Without outliers:

Coefficient values ± one standard deviation

\[ a = -2.31 \pm 1.34 \]
\[ b = 0.92 \pm 0.01 \]
\[ V_{r^2} = 0.878; \]
Mass loading: (ACSM + PAX + Xact) vs TEOM (PM2.5)

Without outliers:
Coefficient values ± one standard deviation

\[ a = 9.004 \pm 1.91 \]
\[ b = 0.868 \pm 0.016 \]
\[ r^2 = 0.780; \]
Mass loading: (PM2.5 ACSM + PAX + Xact) vs BAM(PM1.0)

Without outliers:
Coefficient values ± one standard deviation

a = 0.06 ± 1.52
b = 1.003 ± 0.014
V_r2 = 0.869;
PMF

\[ \text{HOA} = 19.7 \times m/z 57 + 0.61 \times m/z 44 \]

\[ \text{OOA} = 4.41 \times m/z 44 \]

![Graphs showing PMF analysis of HOA and OOA concentrations over time with correlation plots and regression lines.](image)
Summary

- For sampling flow rate of 2LPM, very good regression factors between
- About half of PM2.5 mass cannot be detected by PM2.5-ACSM, PAX or Xact-625 in Spring Festival and Lantern Festival.
- Good regressions between mass loading of PM2.5-ACSM and that of TEOM(PM 2.5) or BAM(PM1.0), without outliers measured in Spring Festival and Lantern Festival.
- Lower slopes probably caused by loss of micron particles (Dp1.0-2.5μm) in bends of sampling tube to ACSM, when sampling flow rate increased to 3LPM.
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Thank you!
本图为BAM测得PM1质量浓度与TEOM测得PM2.5质量浓度回归曲线图

Coefficient values ± one standard deviation

\[a = 16.911 \pm 1.44\]

\[b = 0.793 \pm 0.010\]

\[r^2 = 0.827\]
本图为第10页后面一段的放大图