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

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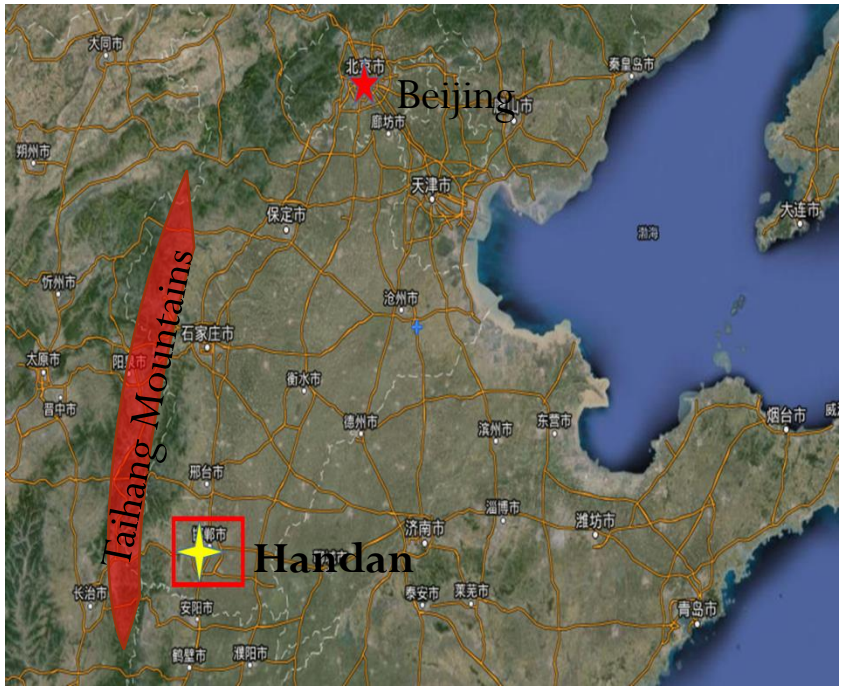
Presented by Ping Chen on Oct. 22 at the 2016 AMS User's Meeting in Portland, Oregon, USA

Background

- 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

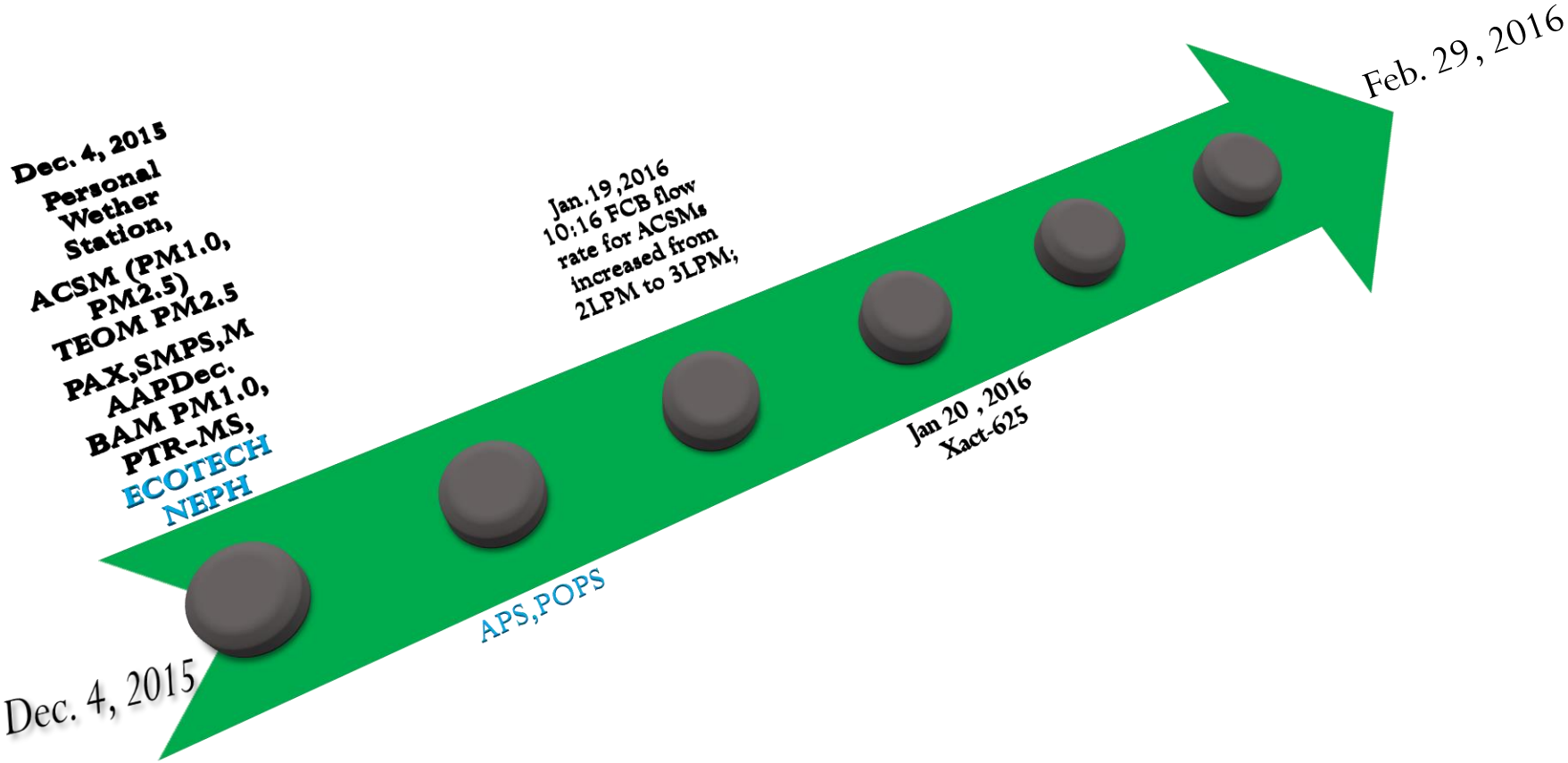
- The sampling site is on the rooftop of a 5-story building on the campus of Hebei University Of Engineering.

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

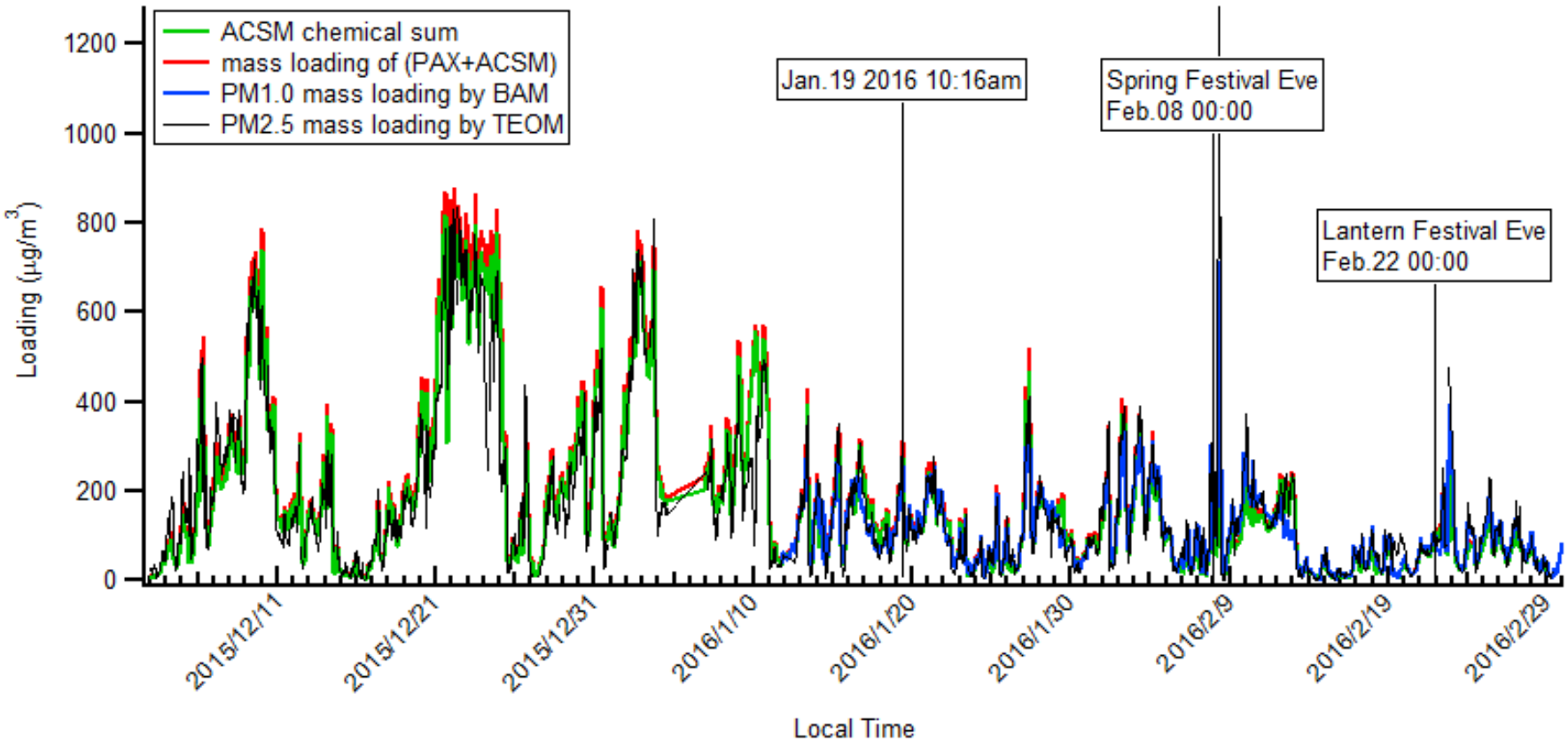
Instruments and Collaborators

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)

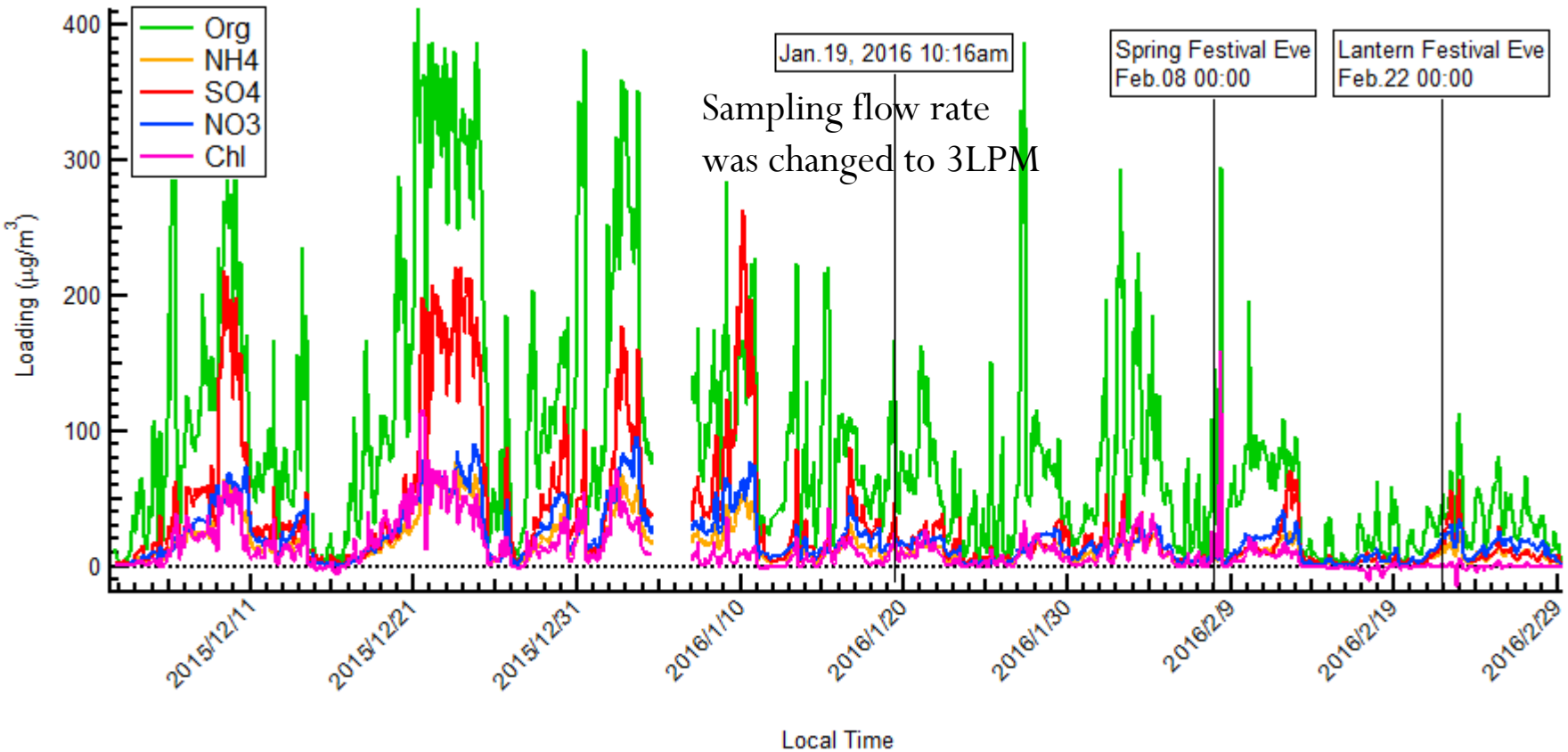
Experiment Timeline



Time Series of PM mass loadings

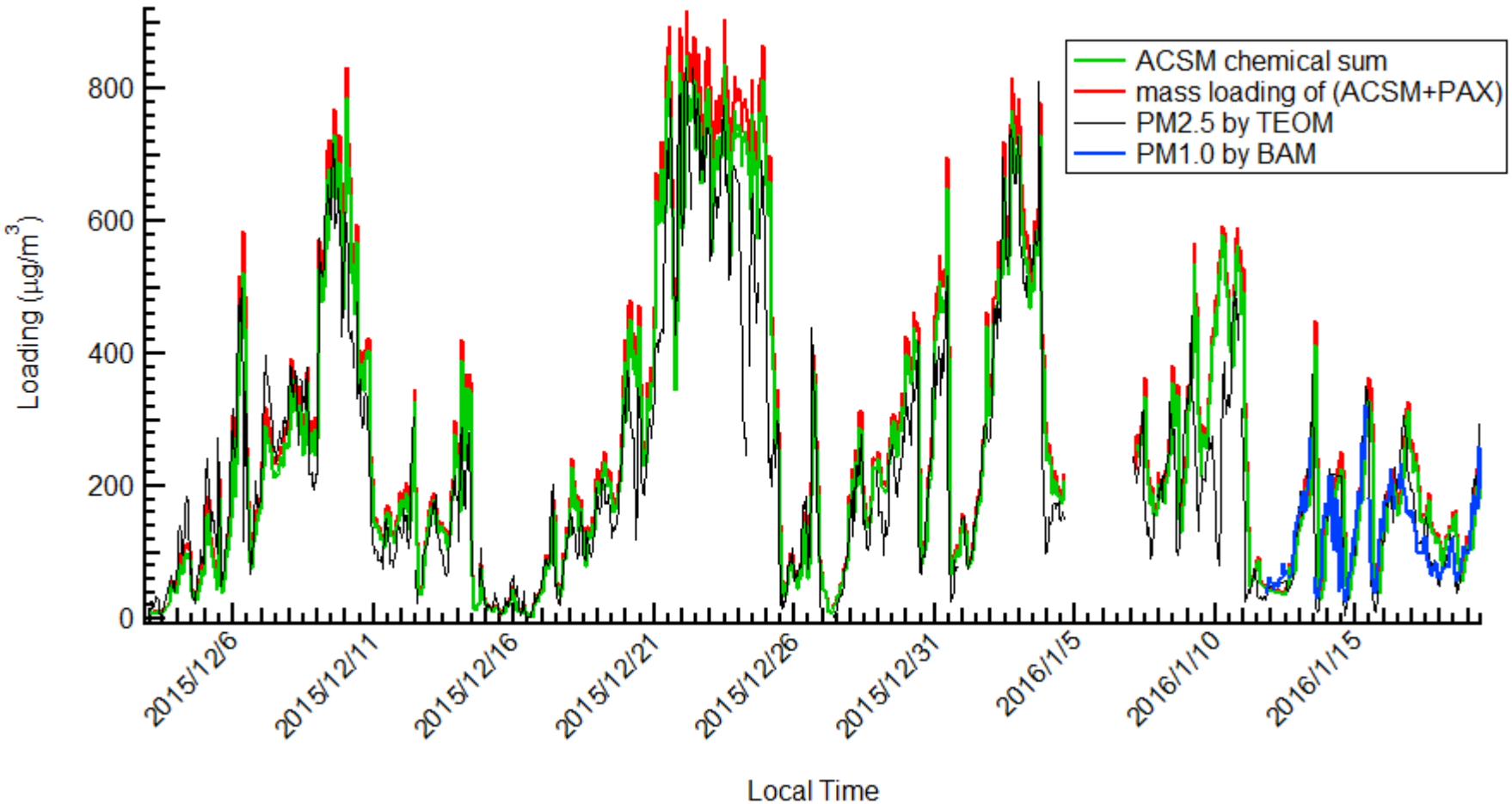


Time Series of PM2.5-ACSM mass loadings

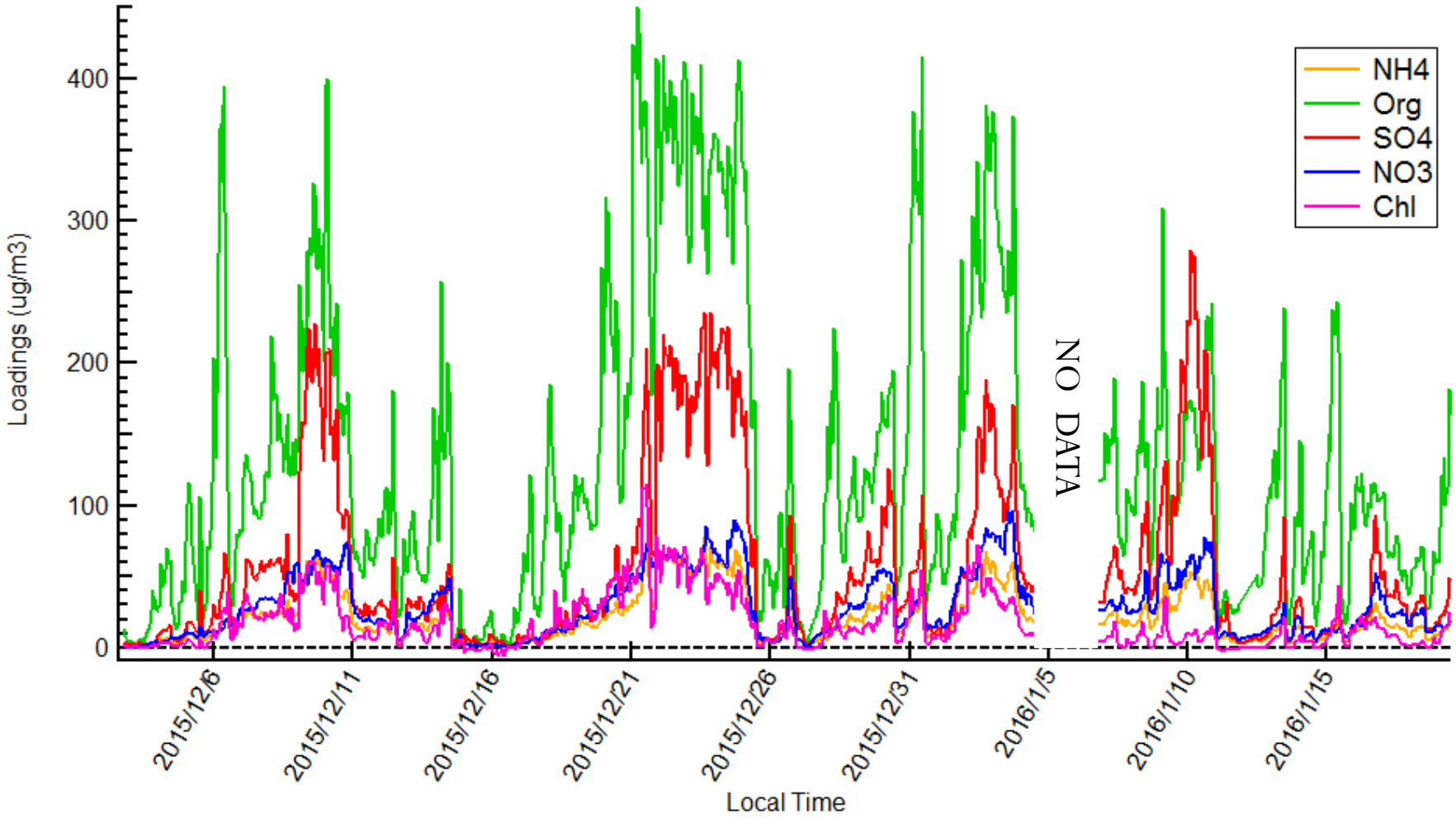


- Flow rate set to 2LPM;

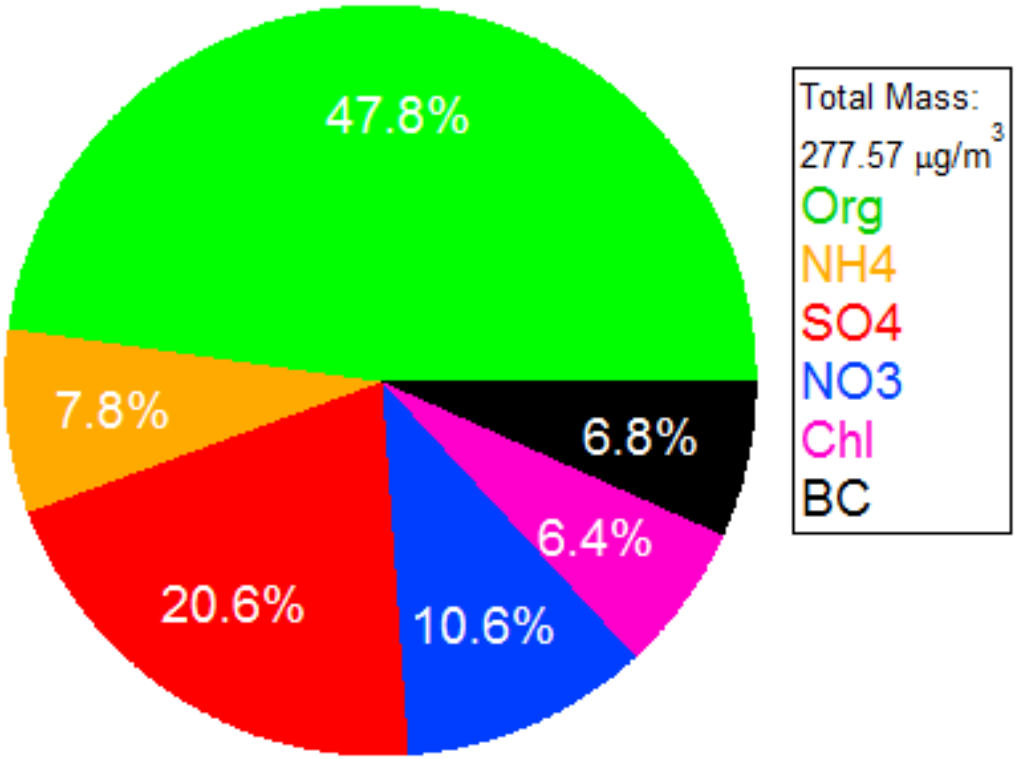
Time Series


ACSM chemical sum
mass loading of (ACSM+PAX)
PM2.5 by TEOM
PM1.0 by BAM
Loading (μg/m3)
0
200
400
600
800
2015/12/6
2015/12/11
2015/12/16
2015/12/21
2015/12/26
2015/12/31
2016/1/5
2016/1/10
2016/1/15
Local Time

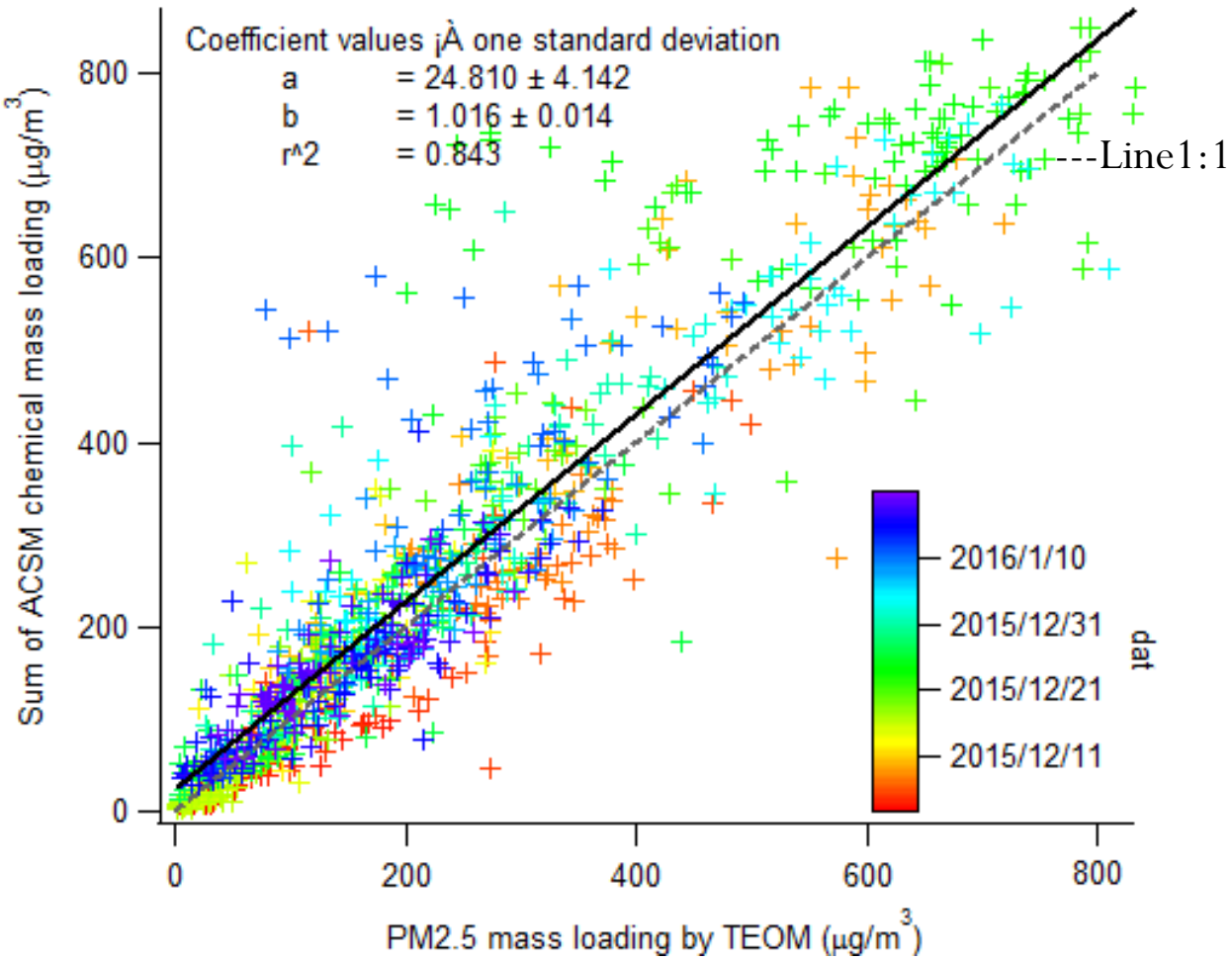
Time Series


Loadings (ug/m3)
400
300
200
100
0
NH4
Org
SO4
NO3
Chl
NO DATA
2015/12/6
2015/12/11
2015/12/16
2015/12/21
2015/12/26
2015/12/31
2016/1/5
2016/1/10
2016/1/15
Local Time

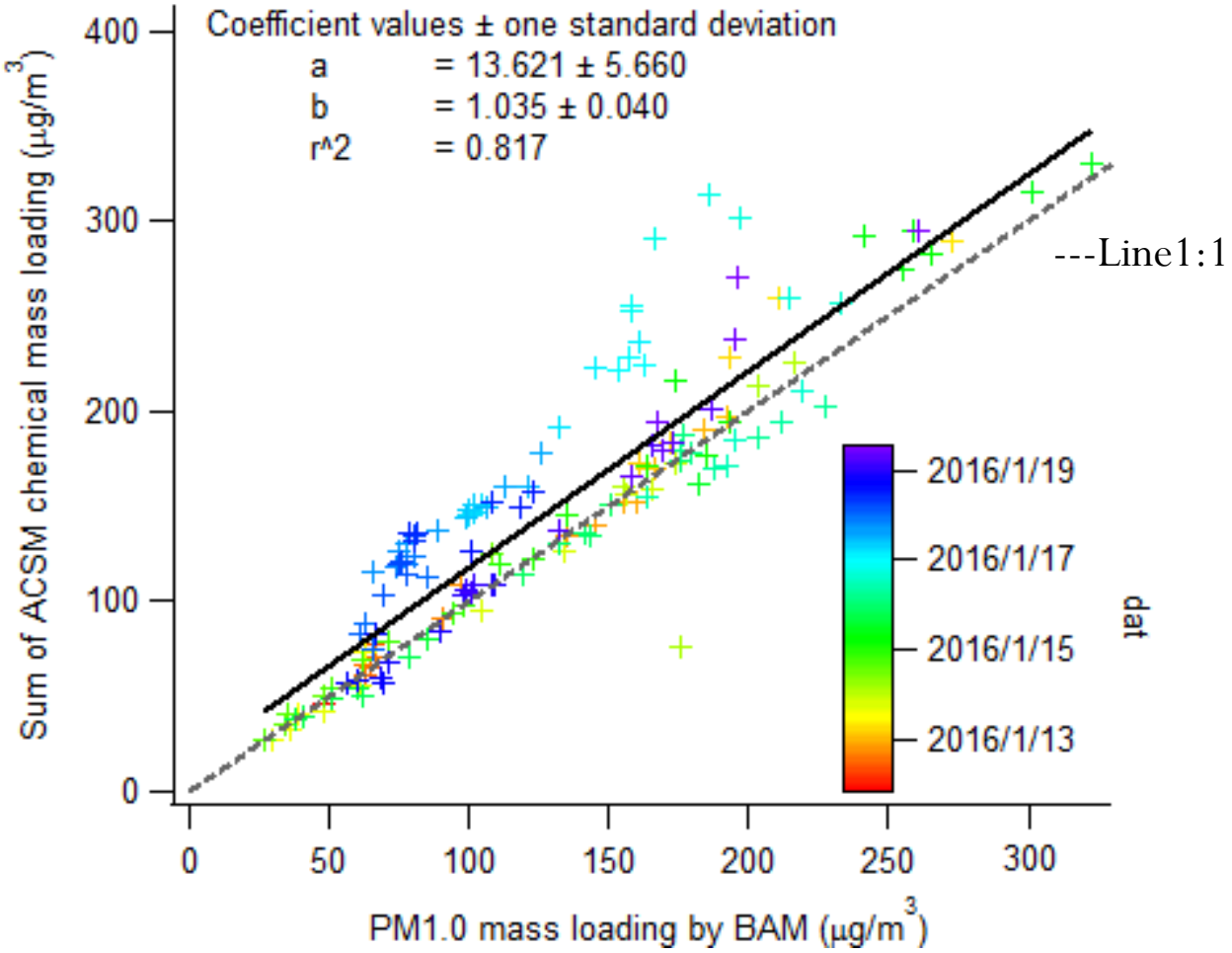
Compositions Pie Chart



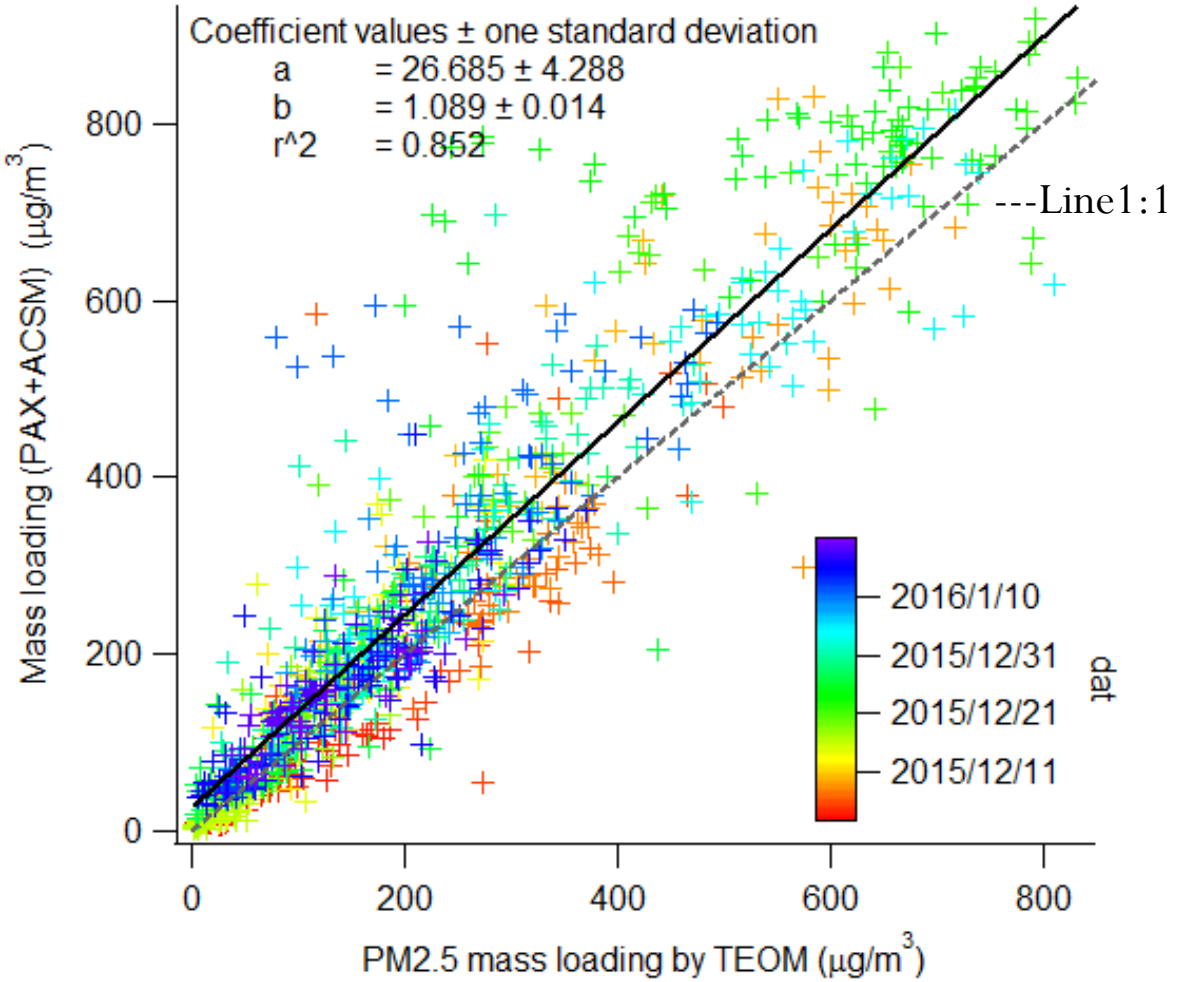
Mass loading : PM2.5-ACSM vs TEOM(PM2.5)



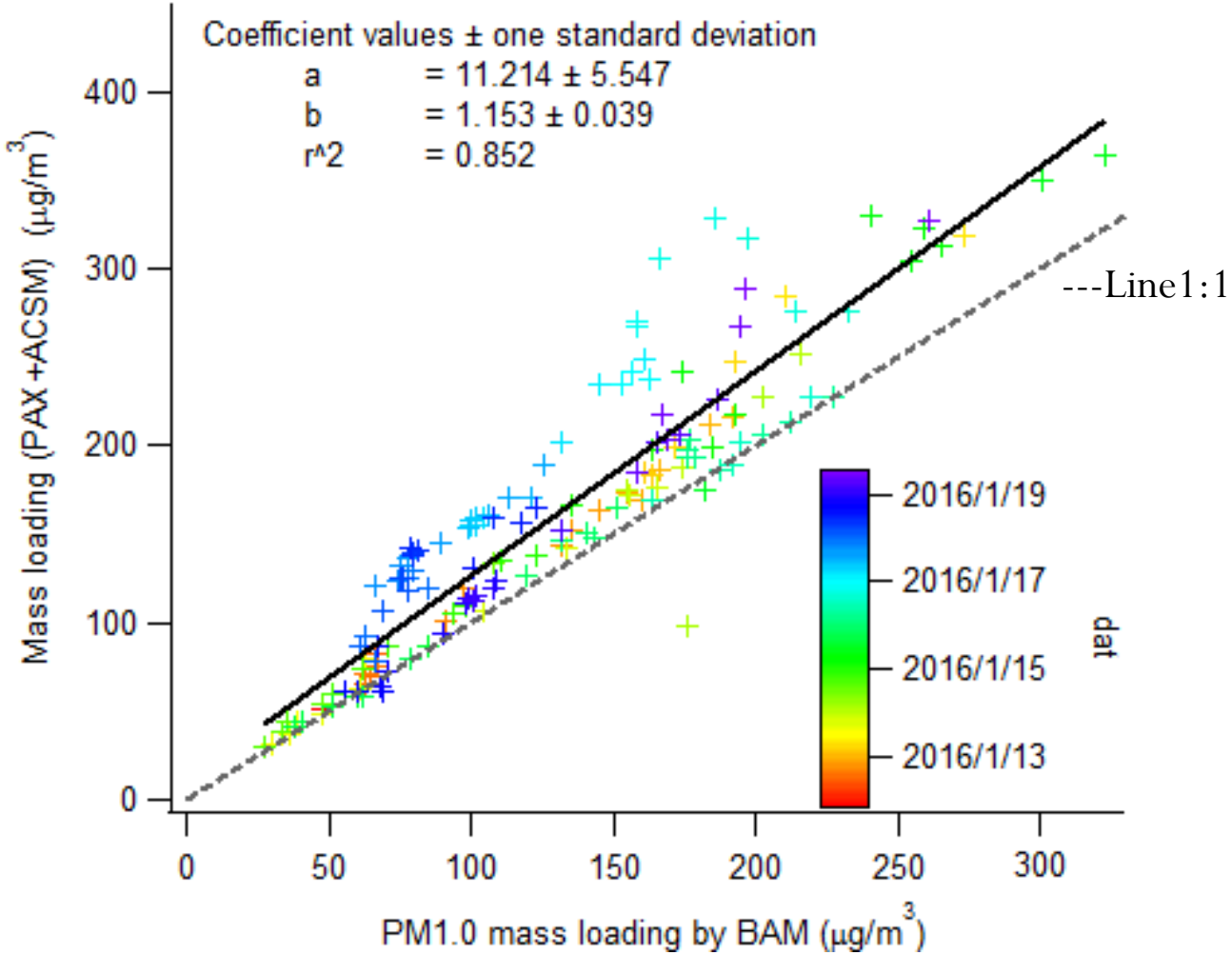
Mass loading : PM2.5-ACSM vs BAM(PM1.0)



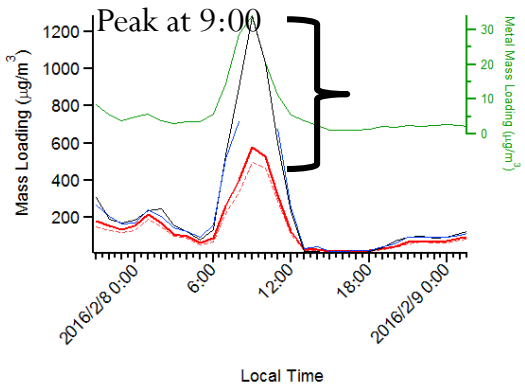
Mass loading : (ACSM +PAX) vs TEOM(PM2.5)

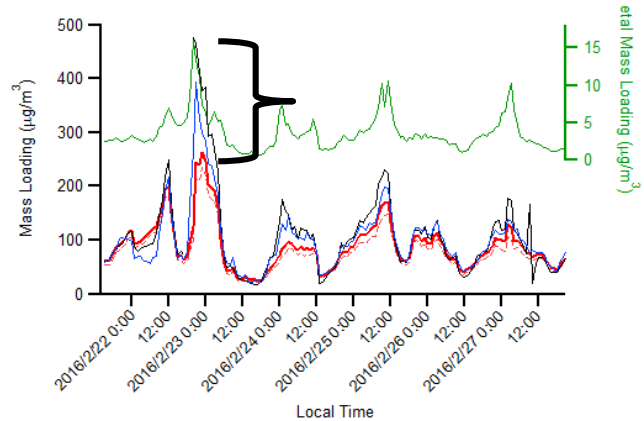


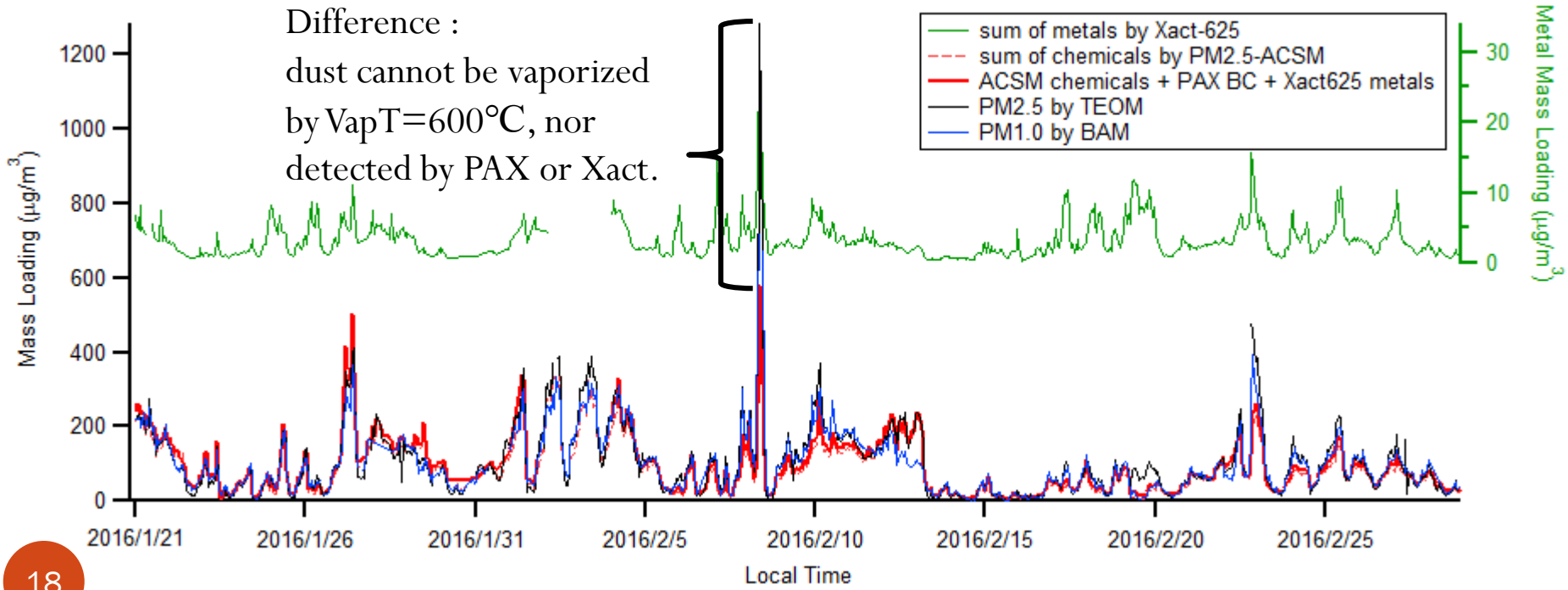
Mass loading : (ACSM +PAX) vs BAM(PM1.0)



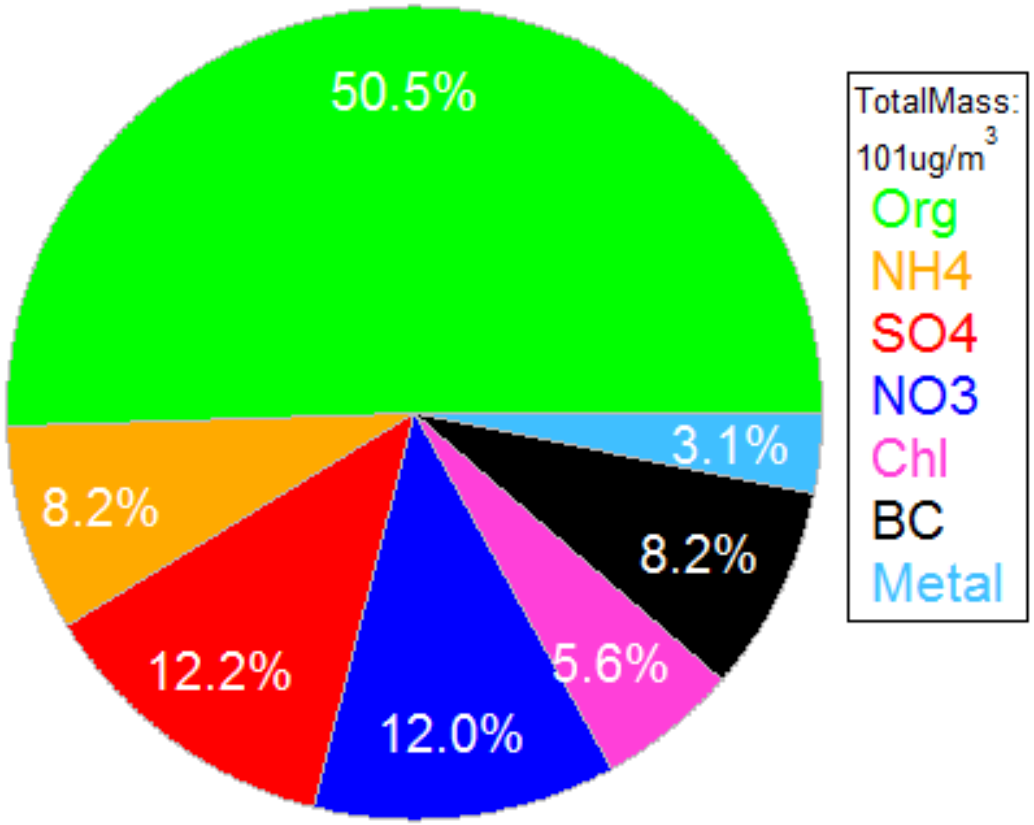
- After the flow rate was changed from 2 LPM to 3LPM on Jan. 16,2016 10:16am;


Peak at 9:00
Mass Loading (µg/m3)
Metal Mass Loading (µg/m3)
Local Time

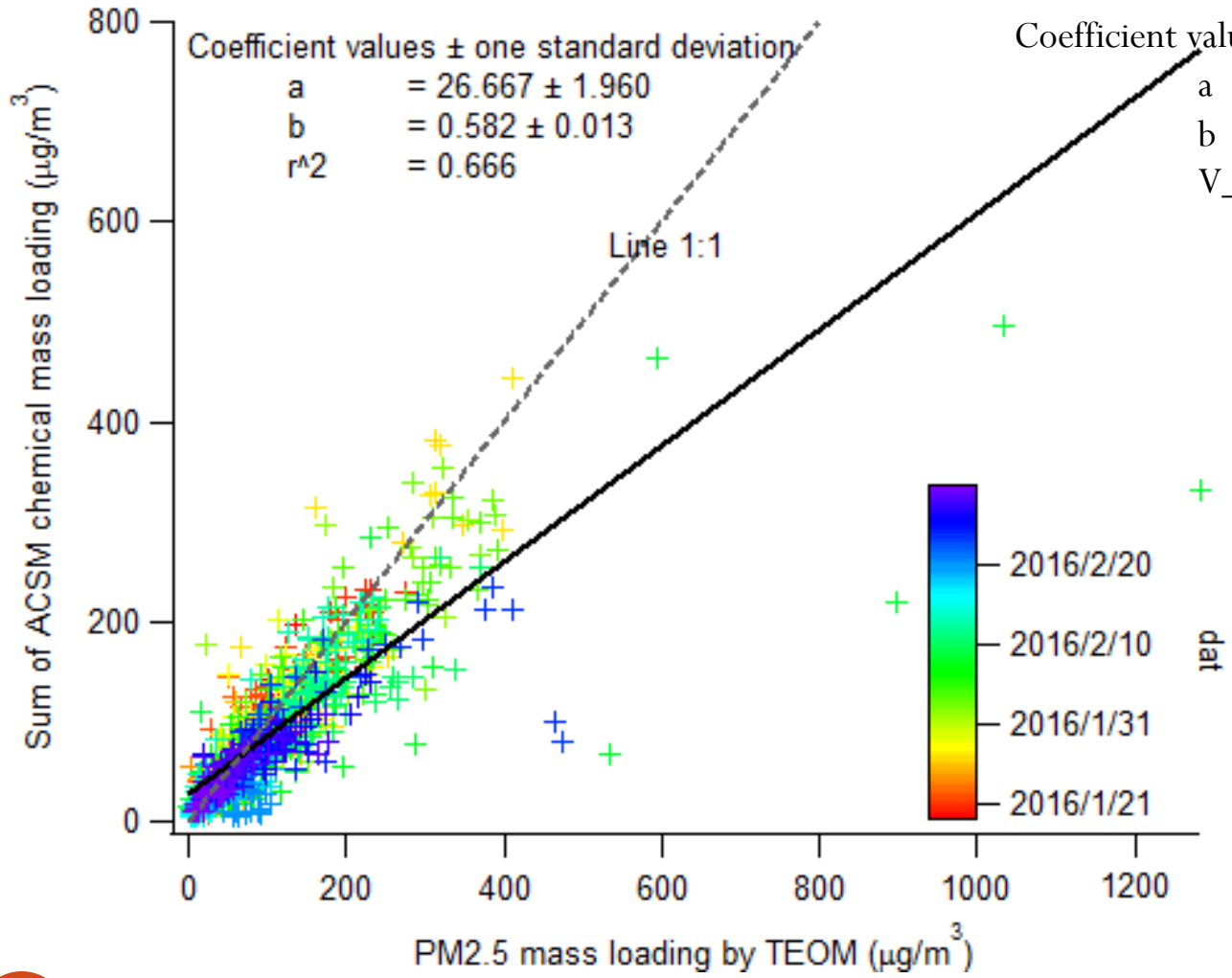

Mass Loading (µg/m3)
Metal Mass Loading (µg/m3)
Local Time


Difference :
dust cannot be vaporized
by VapT=600°C, nor
detected by PAX or Xact.
sum of metals by Xact-625
sum of chemicals by PM2.5-ACSM
ACSM chemicals + PAX BC + Xact625 metals
PM2.5 by TEOM
PM1.0 by BAM
Mass Loading (µg/m3)
Metal Mass Loading (µg/m3)
Local Time

Pie Chart


50.5%
8.2%
12.2%
12.0%
5.6%
8.2%
3.1%
TotalMass:
101ug/m3
Org
NH4
SO4
NO3
Chl
BC
Metal

Mass loading : PM2.5-ACSM vs TEOM(PM2.5)



Without outliers:

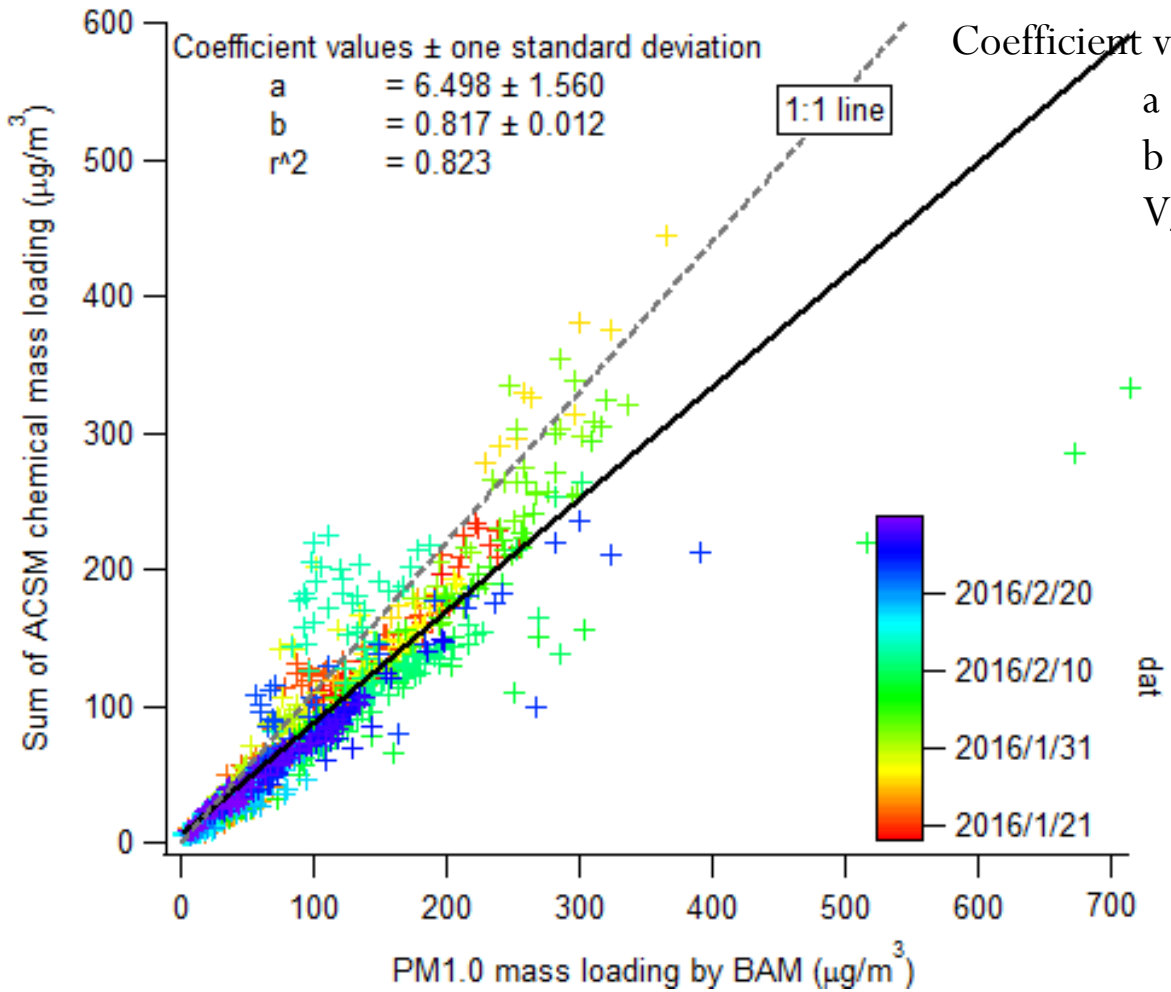
Coefficient values ± one standard deviation

a = 9.88 ± 1.67

b = 0.76 ± 0.0128

V_r2 = 0.789;

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



Without outliers:

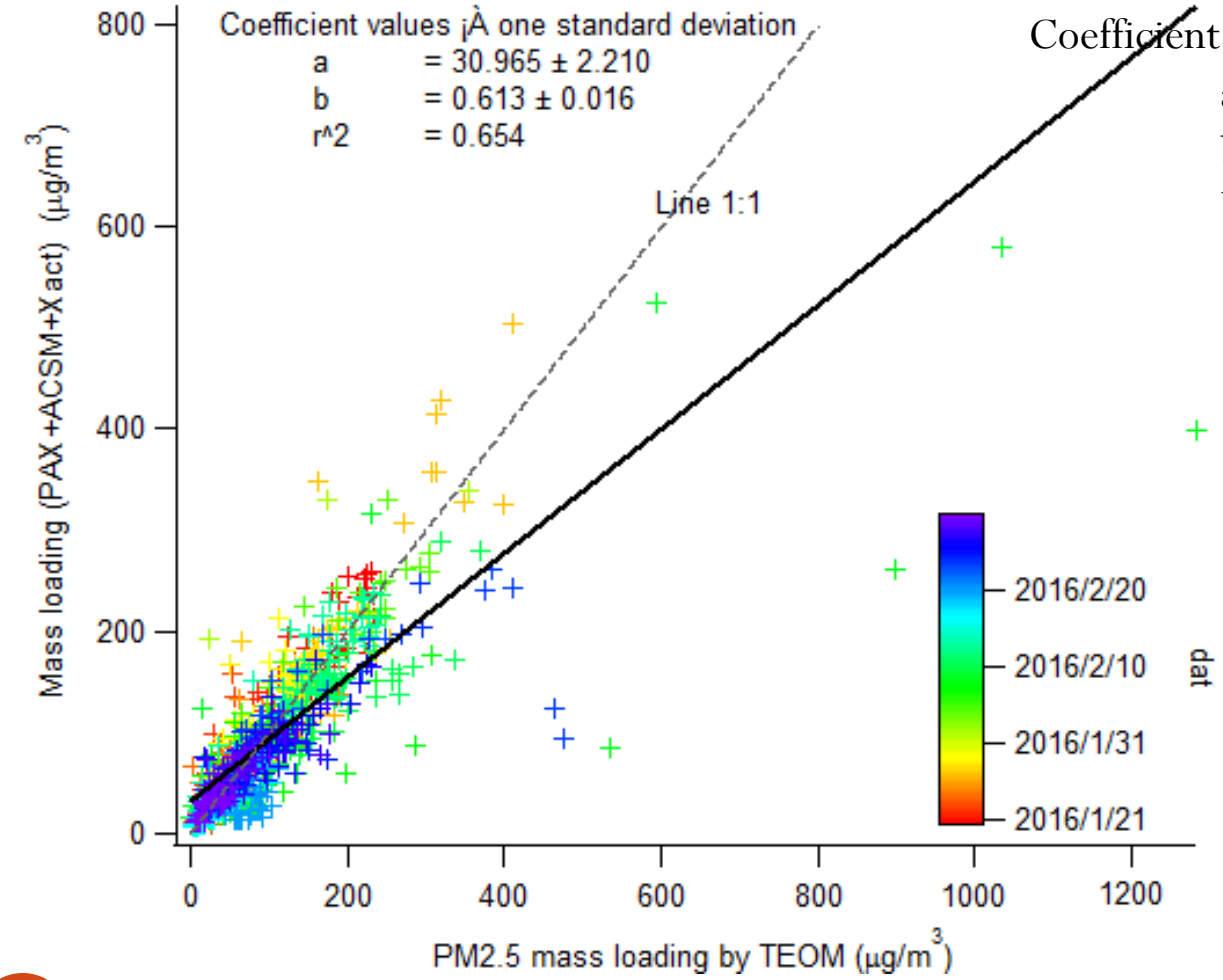
Coefficient values ± one standard deviation

a = -2.31 ± 1.34

b = 0.92 ± 0.01

V_r2= 0.878;

Mass loading : (ACSM +PAX+Xact) vs TEOM(PM2.5)



Without outliers:

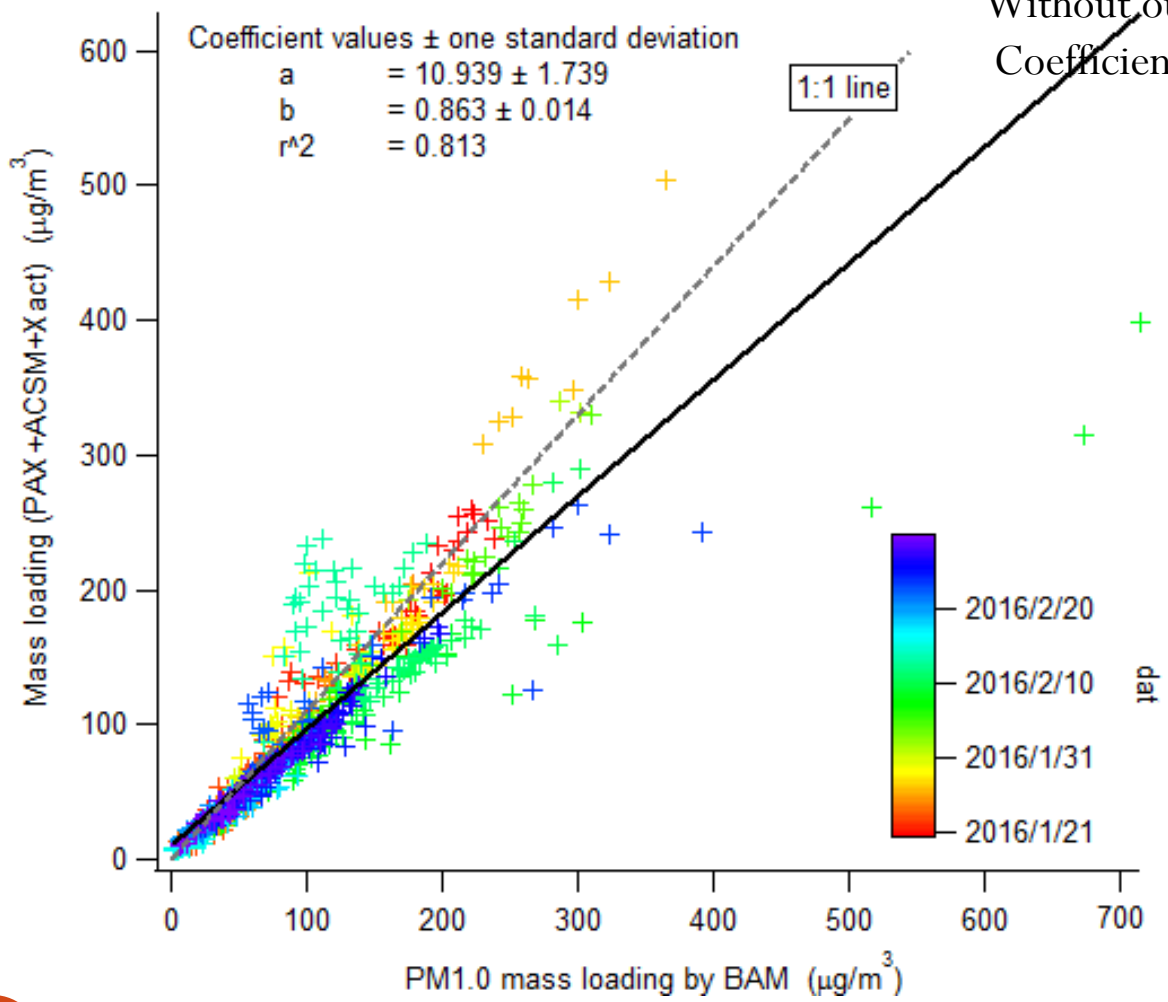
Coefficient values ¡À one standard deviation

a =9.004 ± 1.91

b =0.868 ± 0.016

V_r2= 0.780;

Mass loading : (PM2.5 ACSM + PAX + Xact) vs BAM(PM1.0)



Without outliers:

Coefficient values ¡À one standard deviation

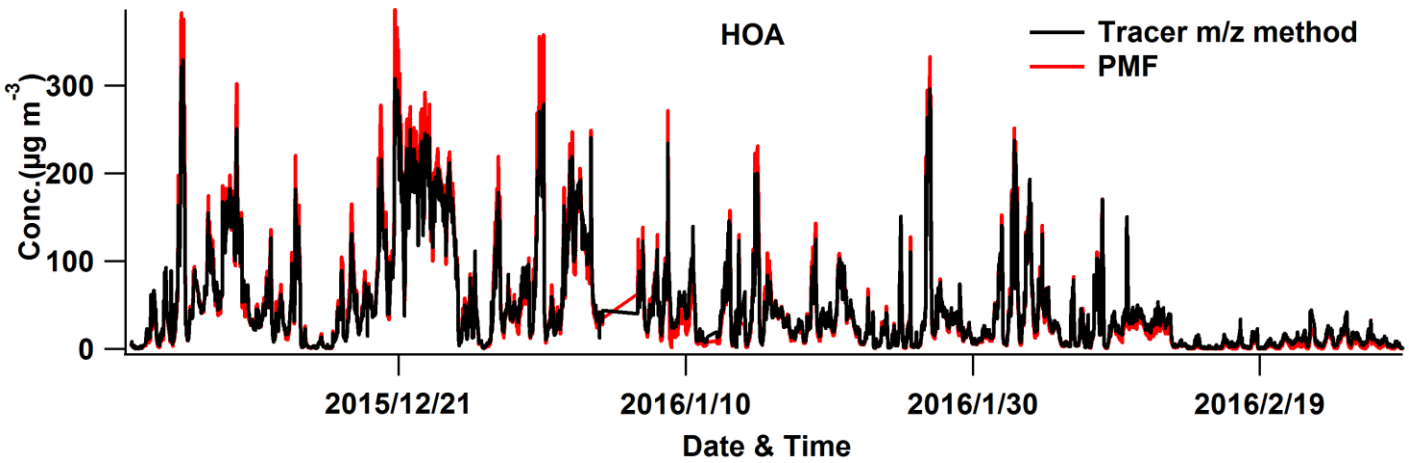
a =0.06 ± 1.52

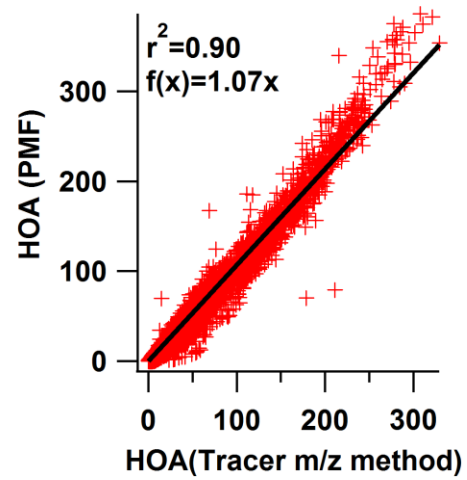
b =1.003 ± 0.014

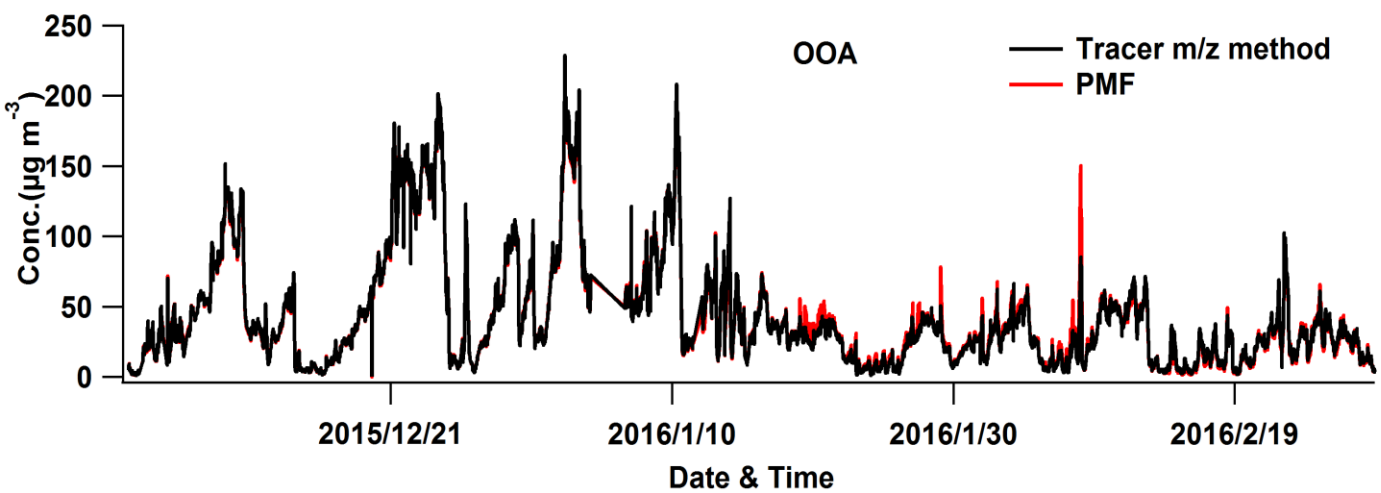
V_r2= 0.869;

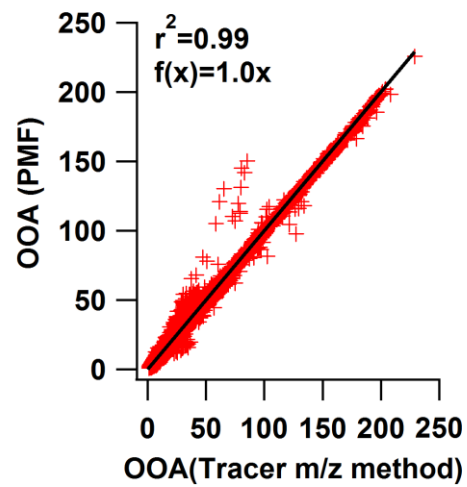
PMF

HOA=19.7*mz57+0.61*mz44
OOA=4.41*mz44









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.

Acknowledgements:

- Haiyan Li, Chunrong Chen and Prof. Qiang Zhang, from Tsinghua University;
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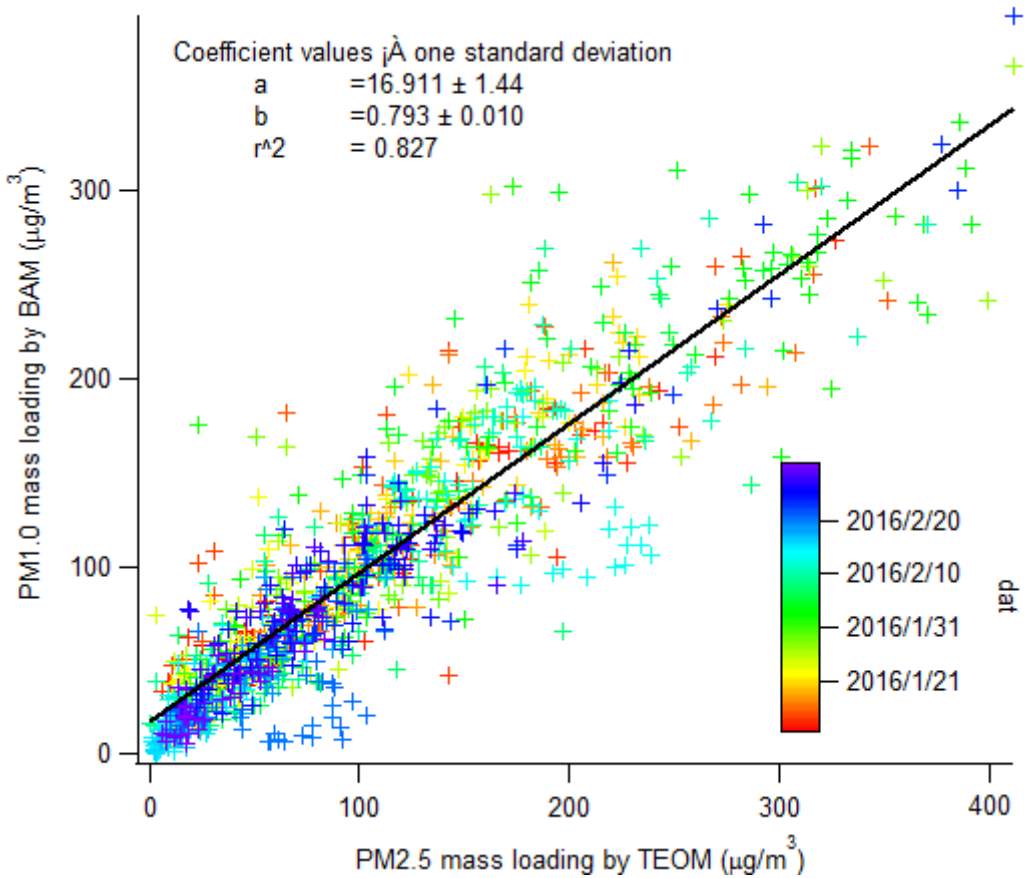
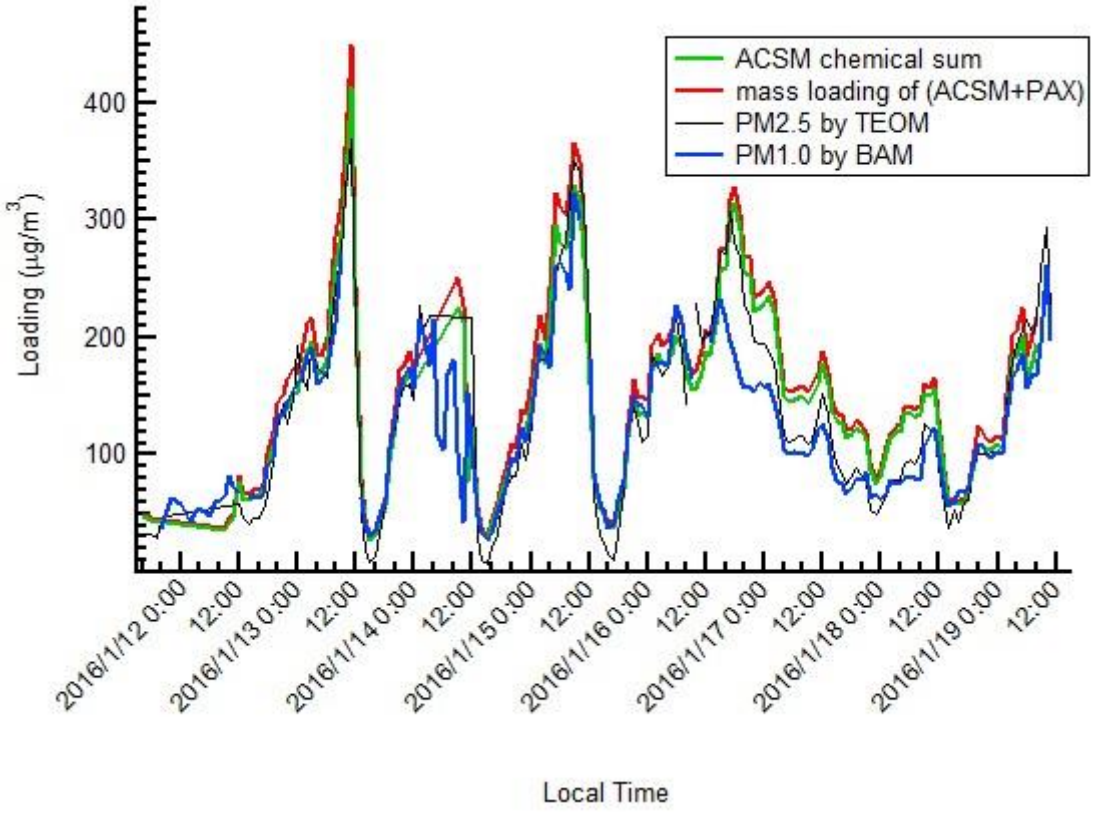
- Dr. Litao Wang, Zhe Wei, Chenchen Meng and Xiao Ma from Hebei University of Engineering;
- Qingzi Meng from Handix;
- Dr. Philip Croteau, from Aerodyne Research Inc.;

Thank you!

备用



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



本图为第10页后面一段的放大图