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Influence of meteorological conditions on air pollutants during an air pollution event in January 2015, Dongshan, China

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YN-center Video Conference

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Outline

- Introduction
- Experiment description
- Results and discussion
- Conclusions
- Recent Work

Introduction

- It is well known that the air pollution concentrations have a close relationship with meteorological factors.

- An air pollution event occurred in Dongshan from 15 to 28 January 2015. In this study, the relationships between ambient air pollutants concentrations and meteorological factors during the air pollution event were examined to give some information for the role meteorological parameters play in the emissions, transport, formation and deposition of air pollutants.

Experiment description

➢ Experiment site

Measurements and data analysis

- Experimental period: 15th to 28th January 2015.
- Hourly mean mass concentrations of $PM_{2.5}$, PM_{10}, SO_2, CO, O_3 and NO_2 were measured by the TEOM Series 1405 Ambient Particulate Monitor.
- Conventional observation meteorological data from the Dongshan automatic meteorological station were used to define meteorological conditions.
- Backward trajectory analysis was performed using the HYSPLIT model with NCEP reanalysis products provided by the NOAA.

Results and discussions

➢ Concentrations of air pollutants

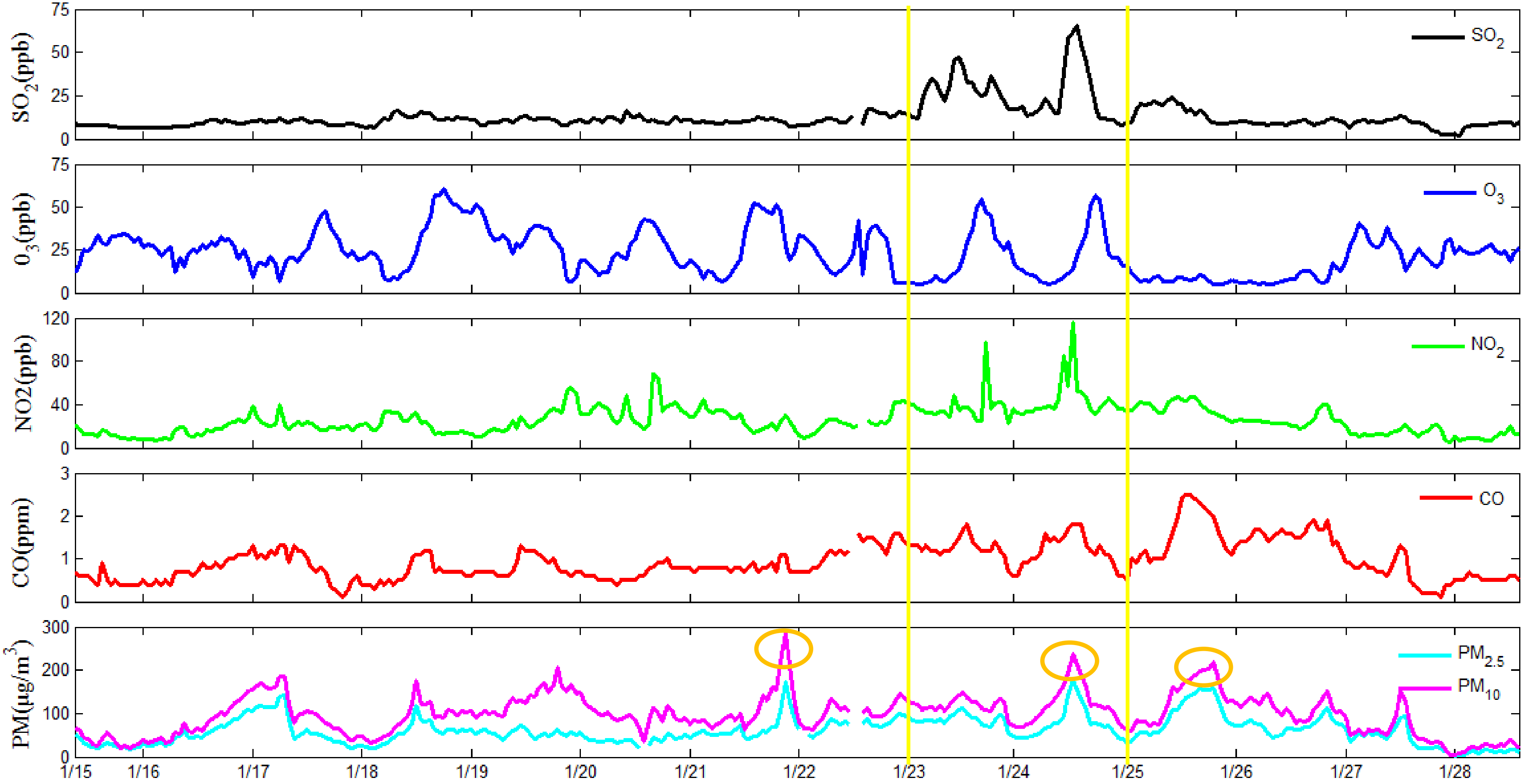


Figure 1. Time series of the concentrations of particulate matters (PM$_{2.5}$ and PM$_{10}$) and trace gases (SO$_2$, CO, O$_3$, NO$_2$)

Table 1. Statistical summary on the concentrations of particulate matters and trace gases

	$PM_{2.5}$（μg/m^3）	**PM_{10}（μg/m^3）**	**O_3（μg/m^3）**	**CO（mg/m^3）**	**SO_2（μg/m^3）**	**NO_2（μg/m^3）**	**PM_{25}/PM_{10}**
average	61.50	98.21	48.73	1.19	36.74	53.23	0.63
Standard deviation	32.22	46.50	28.46	0.56	24.39	28.23	0.14
maximum	177.10	285.00	129.68	3.13	186.00	238.79	0.93
Minimum	2.10	5.10	10.65	0.13	5.43	12.19	0.30

Table 2. The pollution days defined by the National Ambient Air Quality Standards

	Pollution days
$PM_{2.5}$（μg/m^3）	1/22、1/23、1/24、1/25
O_3（μg/m^3）	1/18
NO_2（μg/m^3）	1/24

➢ $PM_{2.5}/PM_{10}$

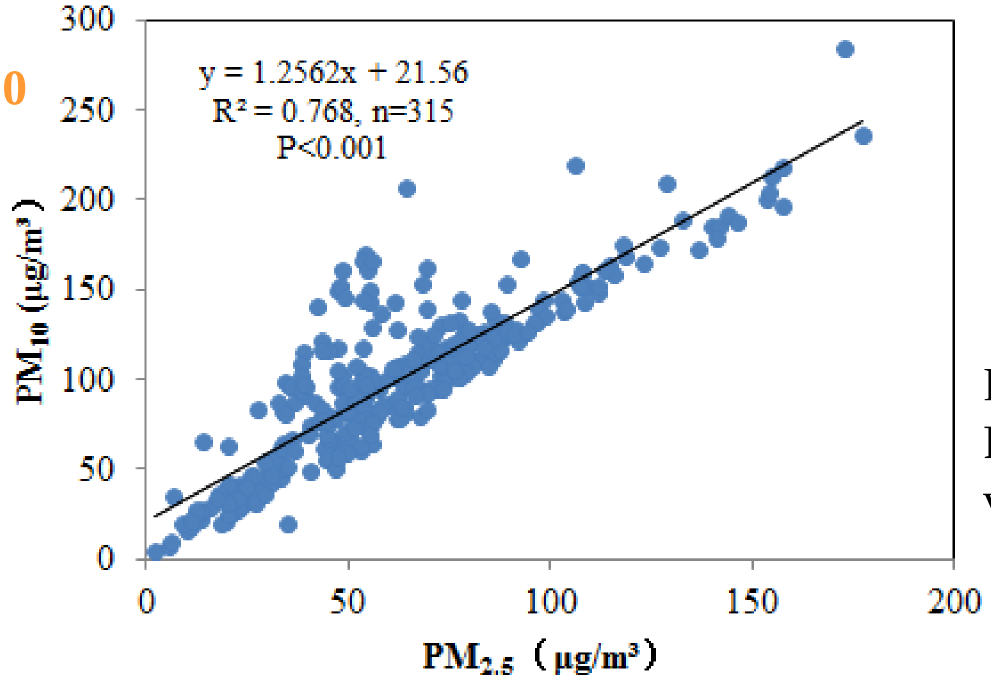


Figure 2. Scatter plots of $PM_{2.5}$ concentration vs. PM_{10} concentration

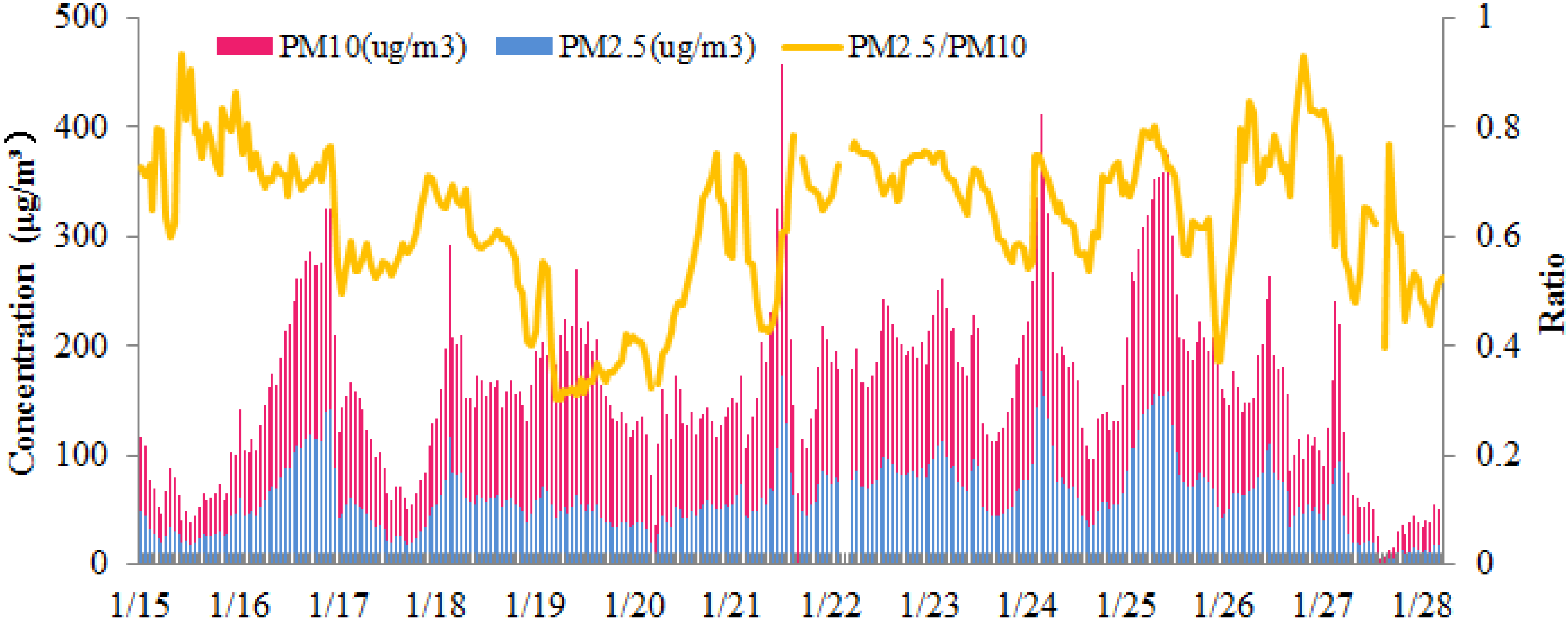


Figure 3. Time series of particle mass concentrations and $PM_{2.5}$ / PM_{10}

➢ Relationship between air pollutants and meteorological variables

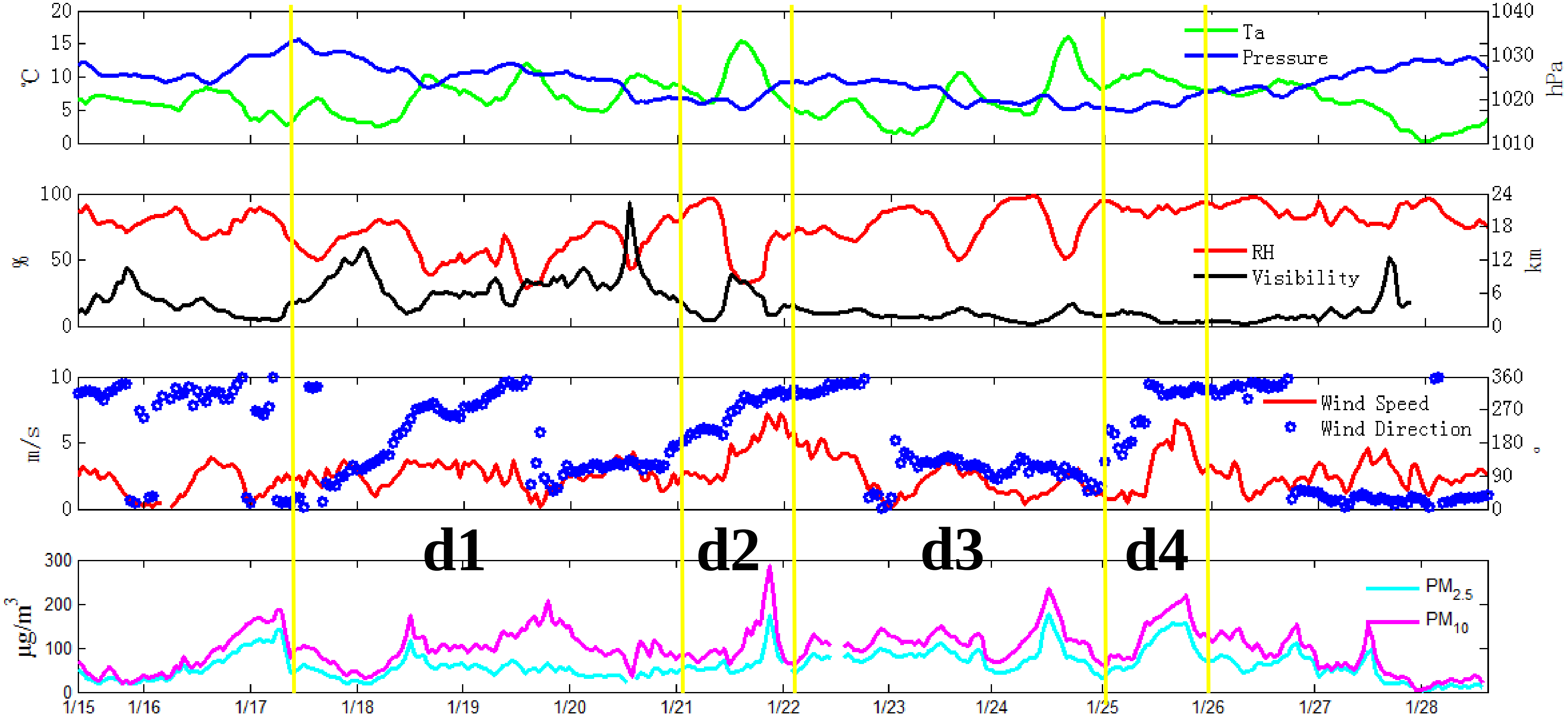


Figure 4. Time series of particle mass concentrations and meteorological variables

Table 3. Correlations between air pollutants and meteorological parameters

	$PM_{2.5}$	**PM_{10}**	**CO**	**NO_2**	**SO_2**	**O_3**
Wind Speed	0.278**	0.220**	0.137*	-0.124*	-0.053	0.257**
≤3m/s	-0.036	-0.048	-0.065	-0.049	-0.005	0.212**
>3m/s	0.492**	0.509**	0.310**	0.174	-0.085	-0.131
Pressure	-0.306**	-0.278**	-0.433**	-0.500**	-0.403**	0.111*
Temperature	0.294**	0.396**	0.332**	0.274**	0.259**	0.354**
Relative Humidity	0.046	-0.171**	0.171**	0.118*	-0.072	-0.761**
≤60%	0.305*	-0.080	0.036	0.260*	0.180	-0.364**
>60%	0.052	-0.07	0.226**	0.085	-0.068	-0.584**
Visibility	-0.595**	-0.360**	-0.618**	-0.240**	-0.251**	0.434**

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

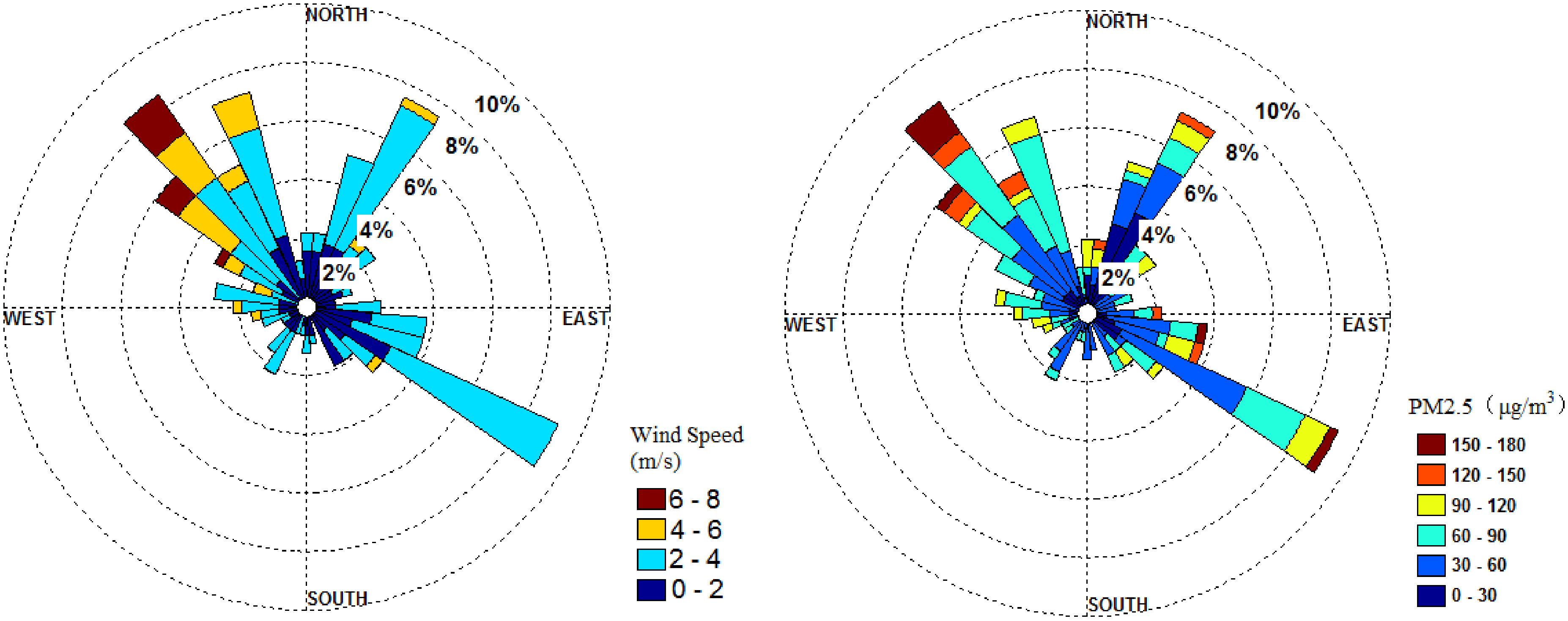


Figure 5. Wind rose and $PM_{2.5}$ rose from hourly data

Table 4. Statistical summary on the $PM_{2.5}$ mass concentrations in different wind directions

$PM_{2.5}$（μg/m^3）	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
average	56.88	52.03	56.65	63.60	56.19	61.69	64.75	70.96
Standard deviation	35.00	31.77	29.62	32.92	10.15	18.82	25.68	36.03
maximum	141.40	140.10	154.50	177.10	83.00	117.60	118.30	172.90
Minimum	2.10	10.10	20.70	18.70	44.40	36.40	23.60	20.40

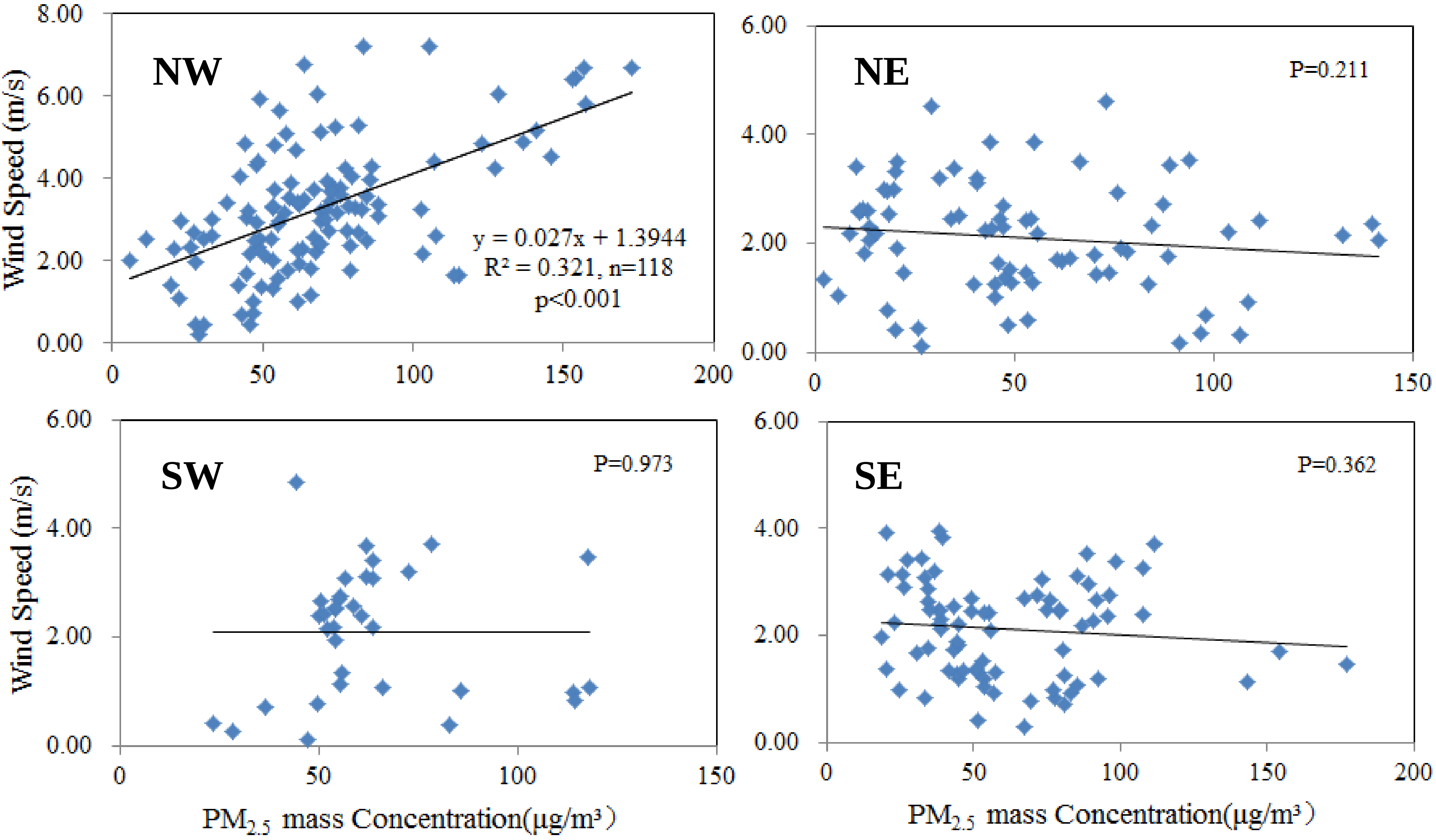


Figure 6. Scatter plots of wind speed vs. $PM_{2.5}$ mass concentration in different wind directions

➢ Air mass backward trajectory analysis

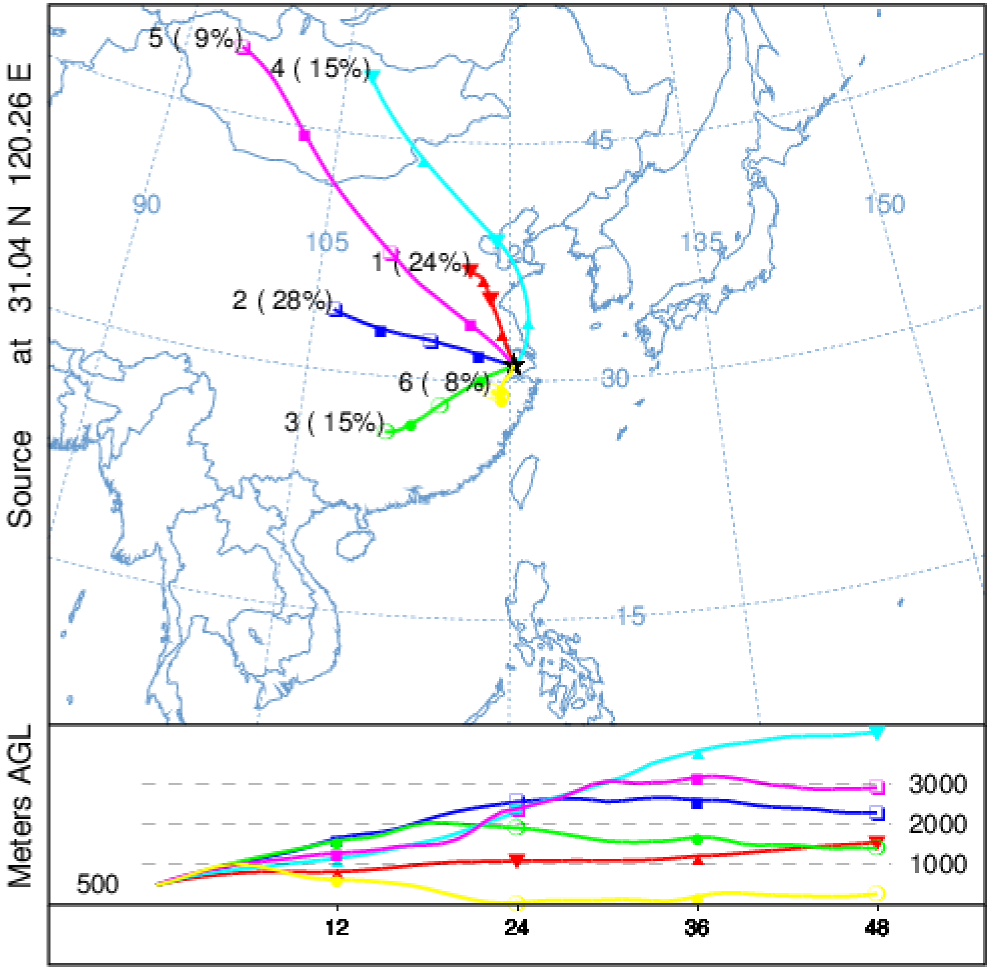


Figure 7. Air masses clusters obtained to 500 m with 48-hour back trajectories

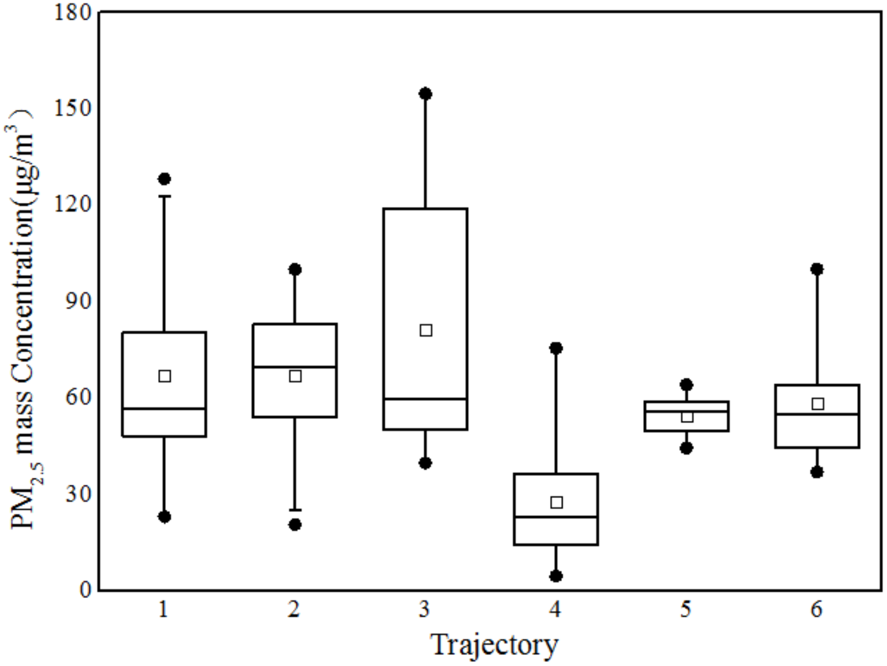


Figure 8. Box plots of $PM_{2.5}$ concentrations under different trajectories

Conclusion

- A Particle matter pollution event was observed in Dongshan from 15th to 28th January 2015. Generally the pollution appeared not very severe because of the Dongshan site is located at suburban areas. The ratio of $PM_{2.5}/PM_{10}$ was 0.63 revealed a significant contribution of $PM_{2.5}$ to PM_{10}.

- Strong correlations between air pollutants and meteorological parameters were found. Particle matter mass concentrations rise with higher relative humidity, temperature and lower air pressure.

- High $PM_{2.5}$ concentrations were mainly affected by the long-distance transport from northwest and local sources from southeast especially the biomass burning while low $PM_{2.5}$ concentrations were affected by the long-distance transport from northeast which blew clean air parcels from the ocean to Dongshan.

Recent work

- Background
- Theory of Sunset semi-continuous OCEC field analyzer
- Results and discussion
- Conclusion
- Future work

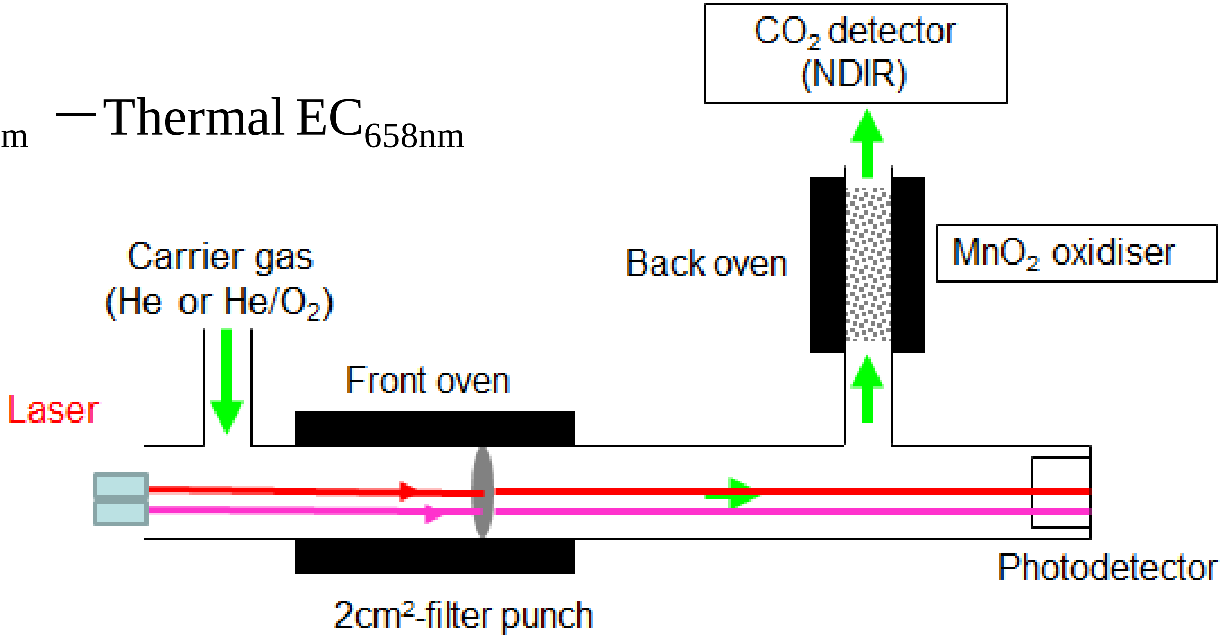
Background

- Organic Carbon (OC) and Elemental Carbon (EC), as the two sub-fractions of particulate matter (PM), play an important role in Climate and human health.
- Except for primary organic carbon (POC), secondary organic (SOC) from atmospheric Photochemical reactions is the main components of Organic Carbon (OC). Fossil fuel and biomass combustion constitute the main origins of Elemental Carbon (EC).
- Recent studies suggest that some light-absorbing organic carbon named as brown carbon (BrC) between OC and EC has been found and proved to be light absorbing in UV-Visible region. China has large BrC emissions from agricultural biomass burning in summer.

Theory of Sunset semi-continuous OCEC field analyzer

Brown Carbon

$dEC = \text{Thermal EC}_{405nm} - \text{Thermal EC}_{658nm}$



Drawn by Dr. Zhang Yanlin

➢ Results and discussion

➢ Comparison between OC and EC concentrations under two lasers of different wavelength

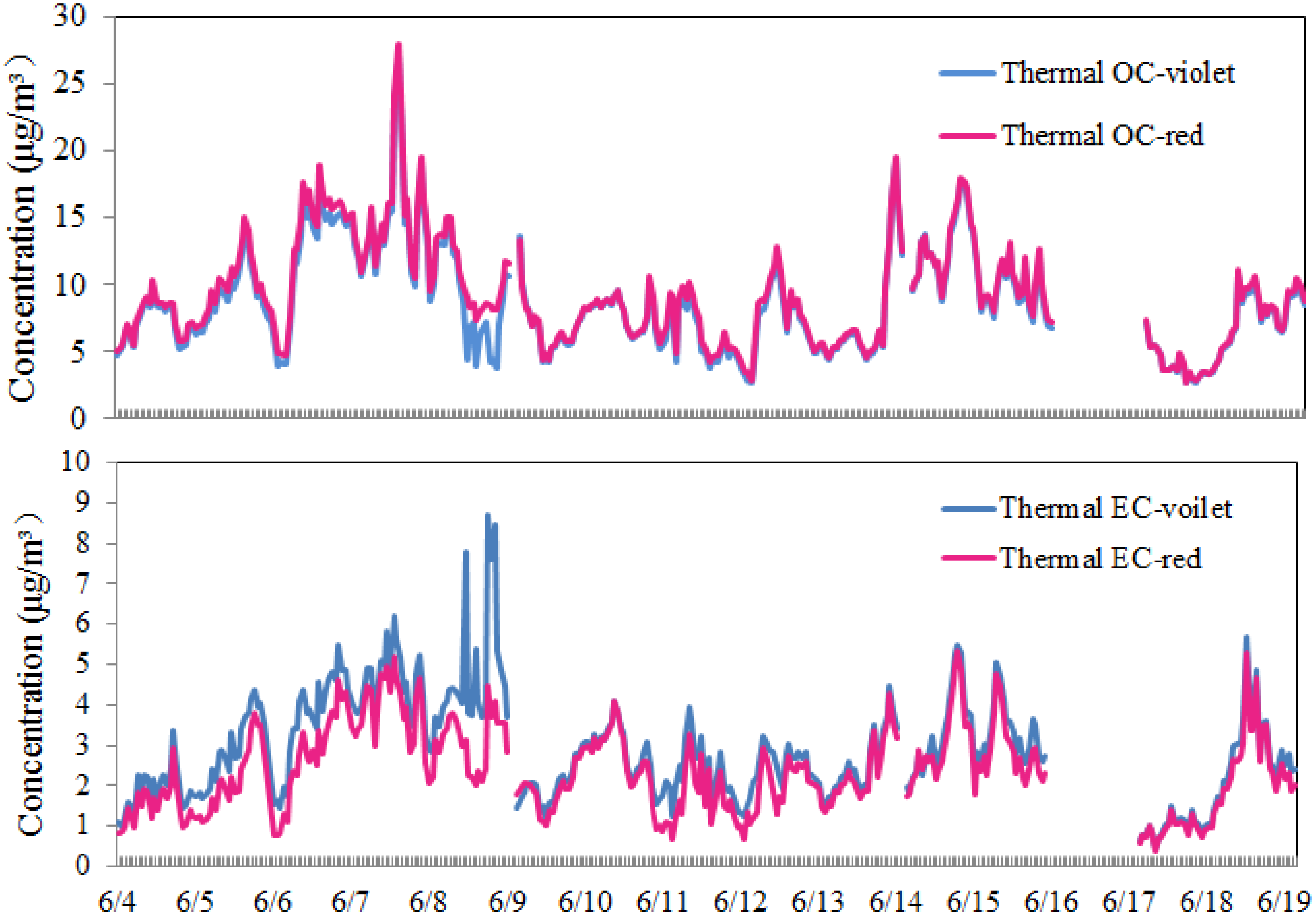


Figure 9. OC and EC-red(658nm) vs. OC and EC-violet(405nm)

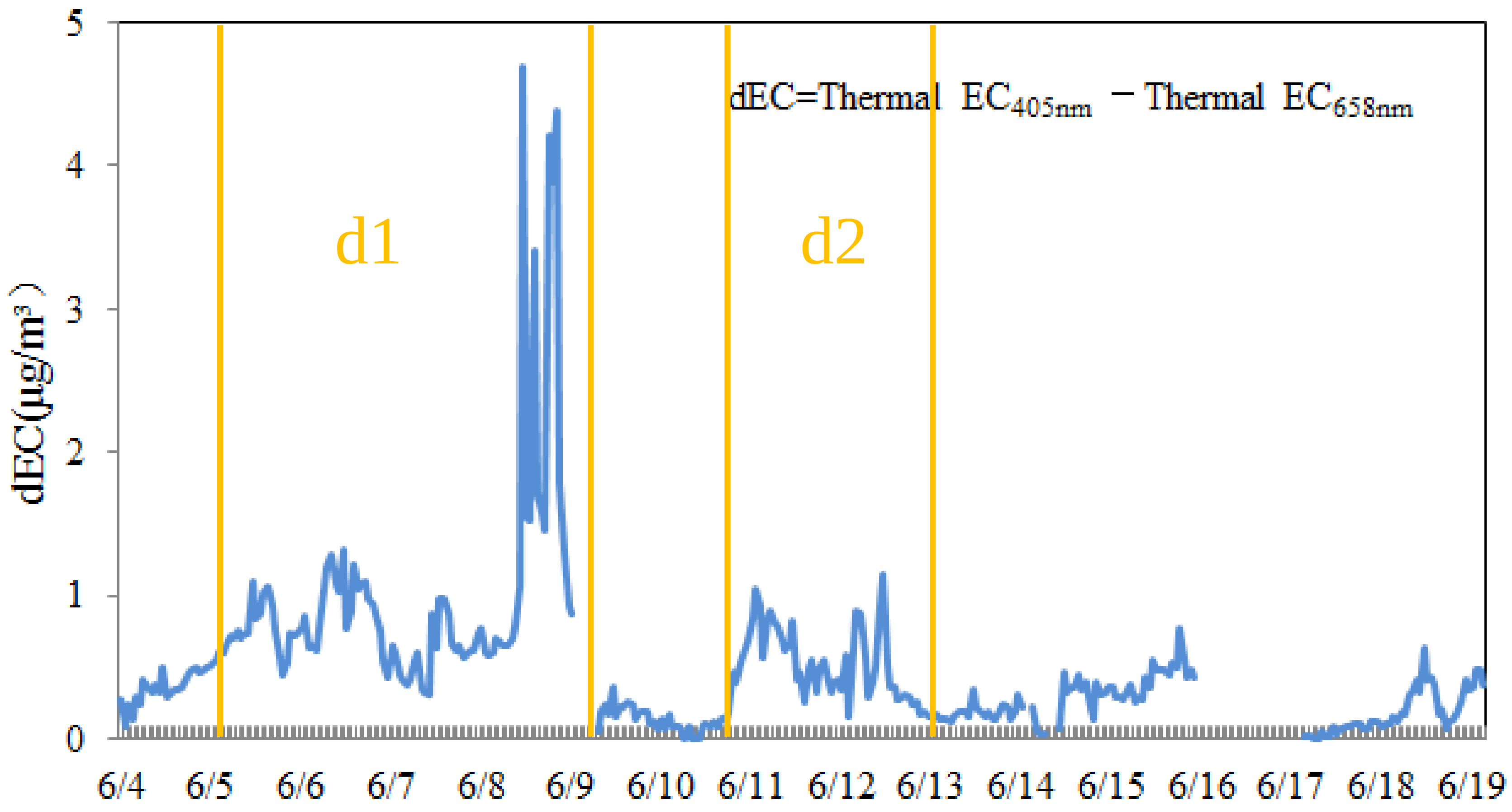
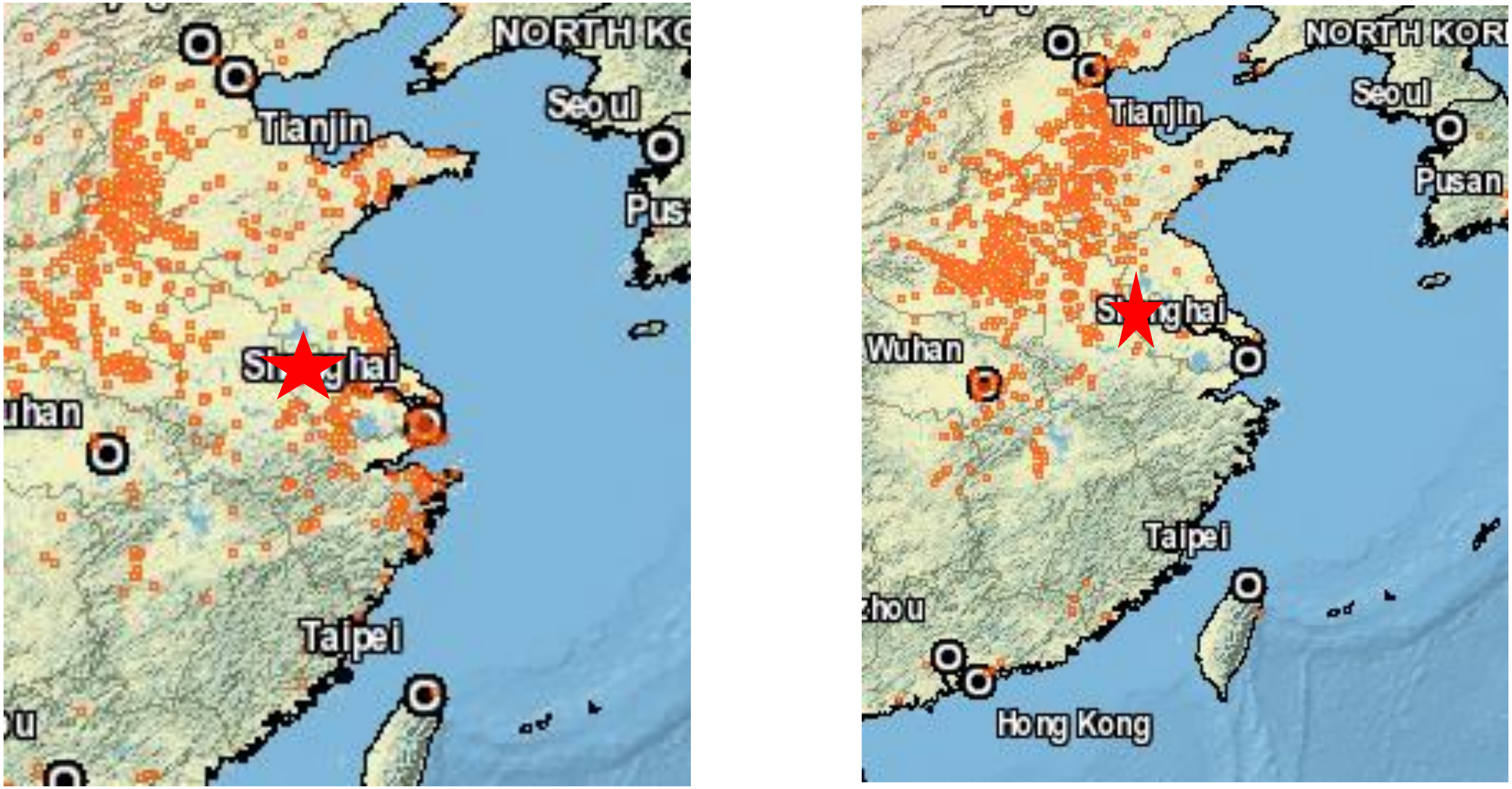


Figure 10. Time series of dEC (Thermal EC_{405nm} —Thermal EC_{658nm})



5th to 9th June

11st to12nd June

Figure 11. Fire pots around Nanjing during 4th to 20th June

➢ Primary vs. secondary organic carbon

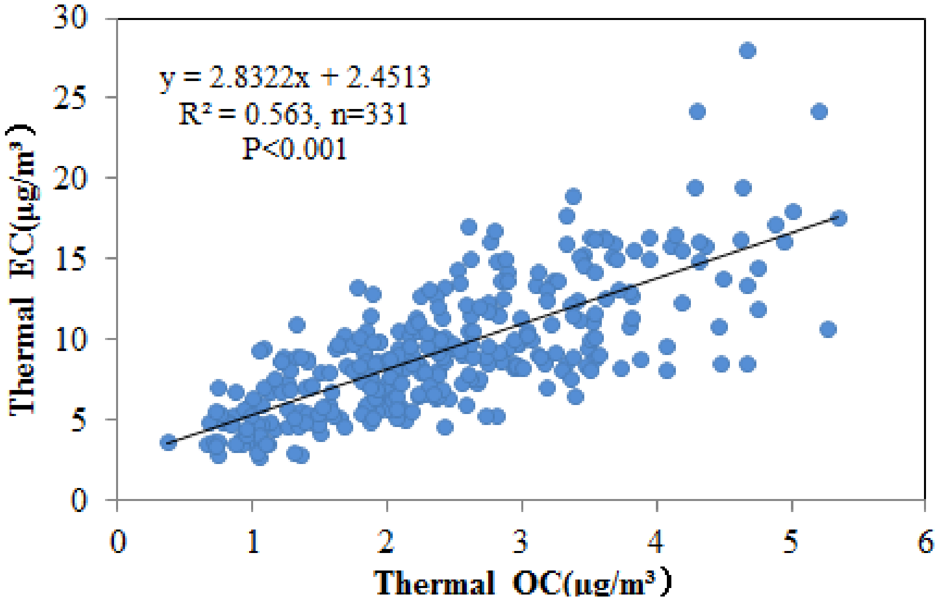


Figure 12. Scatter plots of OC vs. EC(658nm)

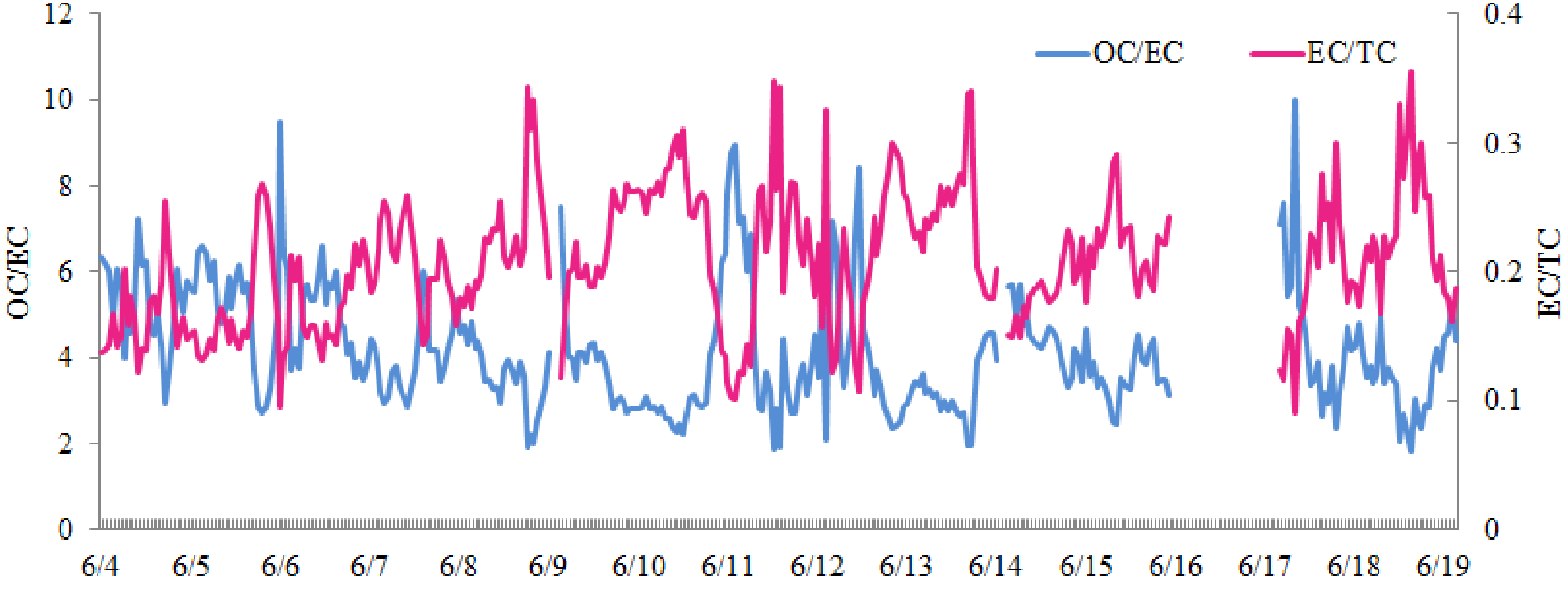


Figure 13. Time series of the ratios of EC to TC and OC to EC(658nm)

Table 5. Statistical summary on OC and EC concentrations(658nm)

658nm	**Thermal OC($\mu g/m^3$)**	**Thermal EC($\mu g/m^3$)**	**TC($\mu g/m^3$)**	**EC:TC**	**OC:EC**
average	9.22	2.39	11.61	0.21	4.13
Standard deviation	3.97	1.05	4.81	0.05	1.37
maximum	28.04	5.35	32.71	0.35	9.99
minimum	2.76	0.37	3.58	0.09	1.82

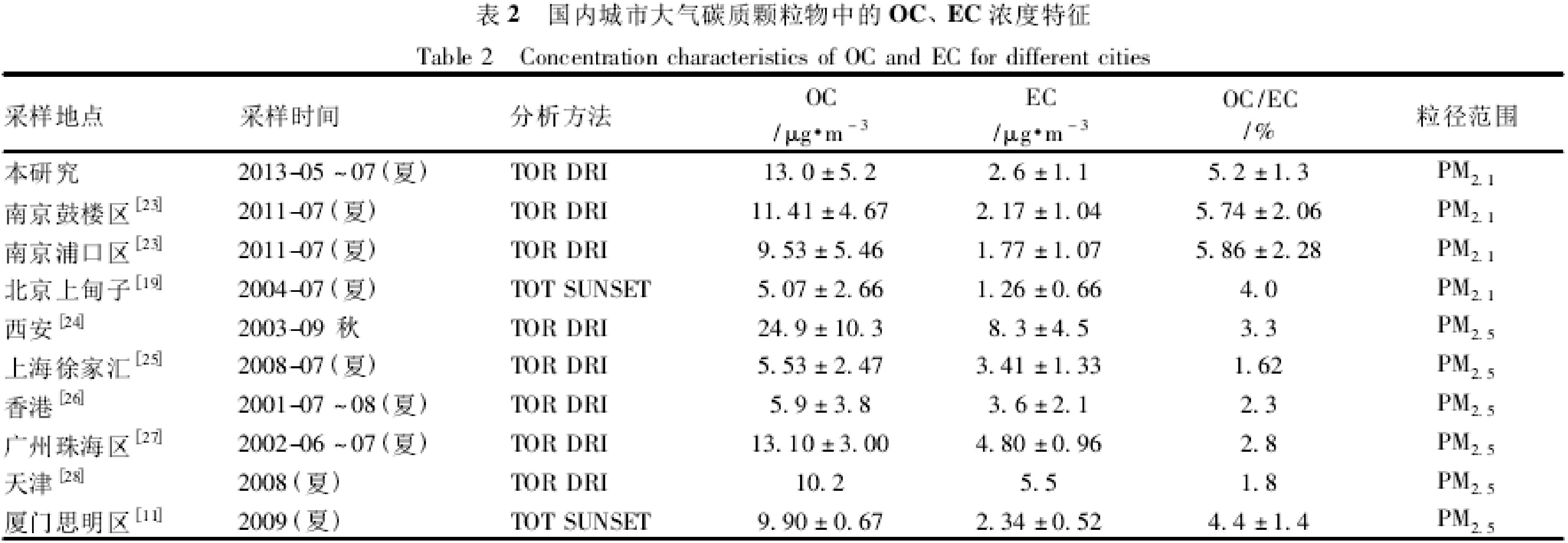


表 **2** 国内城市大气碳质颗粒物中的 **OC**、**EC** 浓度特征

Table 2 Concentration characteristics of OC and EC for different cities

采样地点	采样时间	分析方法	OC $/\mu g \cdot m^{-3}$	EC $/\mu g \cdot m^{-3}$	OC/EC /%	粒径范围
本研究	2013-05～07（夏）	TOR DRI	13.0±5.2	2.6±1.1	5.2±1.3	$PM_{2.1}$
南京鼓楼区[23]	2011-07（夏）	TOR DRI	11.41±4.67	2.17±1.04	5.74±2.06	$PM_{2.1}$
南京浦口区[23]	2011-07（夏）	TOR DRI	9.53±5.46	1.77±1.07	5.86±2.28	$PM_{2.1}$
北京上甸子[19]	2004-07（夏）	TOT SUNSET	5.07±2.66	1.26±0.66	4.0	$PM_{2.1}$
西安[24]	2003-09 秋	TOR DRI	24.9±10.3	8.3±4.5	3.3	$PM_{2.5}$
上海徐家汇[25]	2008-07（夏）	TOR DRI	5.53±2.47	3.41±1.33	1.62	$PM_{2.5}$
香港[26]	2001-07～08（夏）	TOR DRI	5.9±3.8	3.6±2.1	2.3	$PM_{2.5}$
广州珠海区[27]	2002-06～07（夏）	TOR DRI	13.10±3.00	4.80±0.96	2.8	$PM_{2.5}$
天津[28]	2008（夏）	TOR DRI	10.2	5.5	1.8	$PM_{2.5}$
厦门思明区[11]	2009（夏）	TOT SUNSET	9.90±0.67	2.34±0.52	4.4±1.4	$PM_{2.5}$

(By Duan Qing et al, 2014.)

➢ EC vs. CO

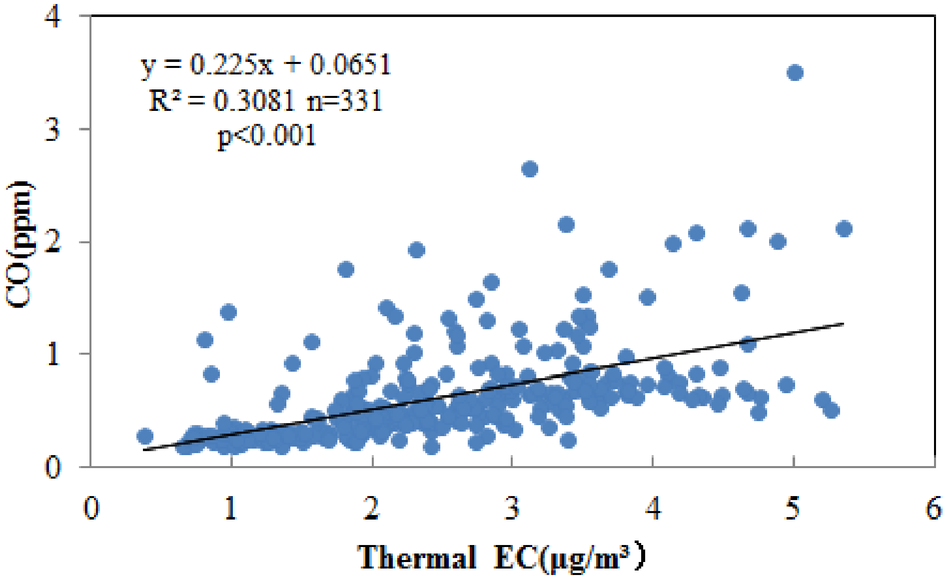


Figure 13. Scatter plots of EC(658nm) vs. CO

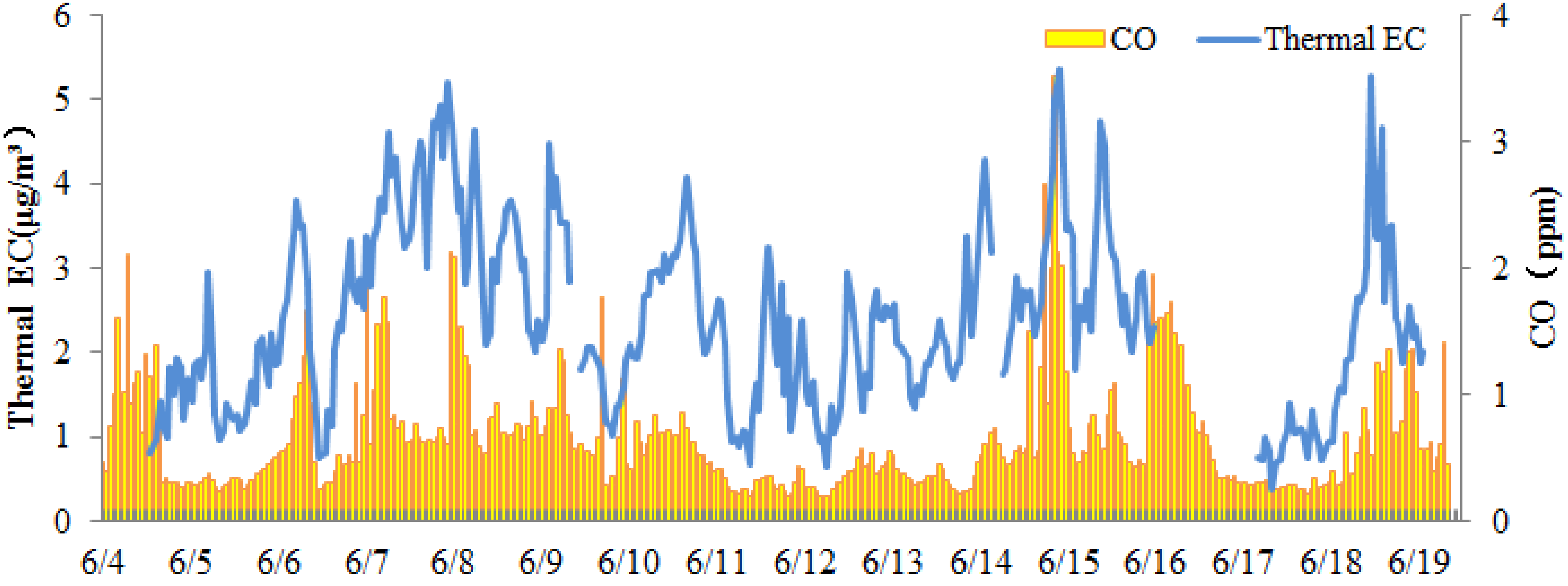


Figure 14. Time series of EC(658nm) and CO

➢ The influence of boundary layer height on OC and EC concentrations

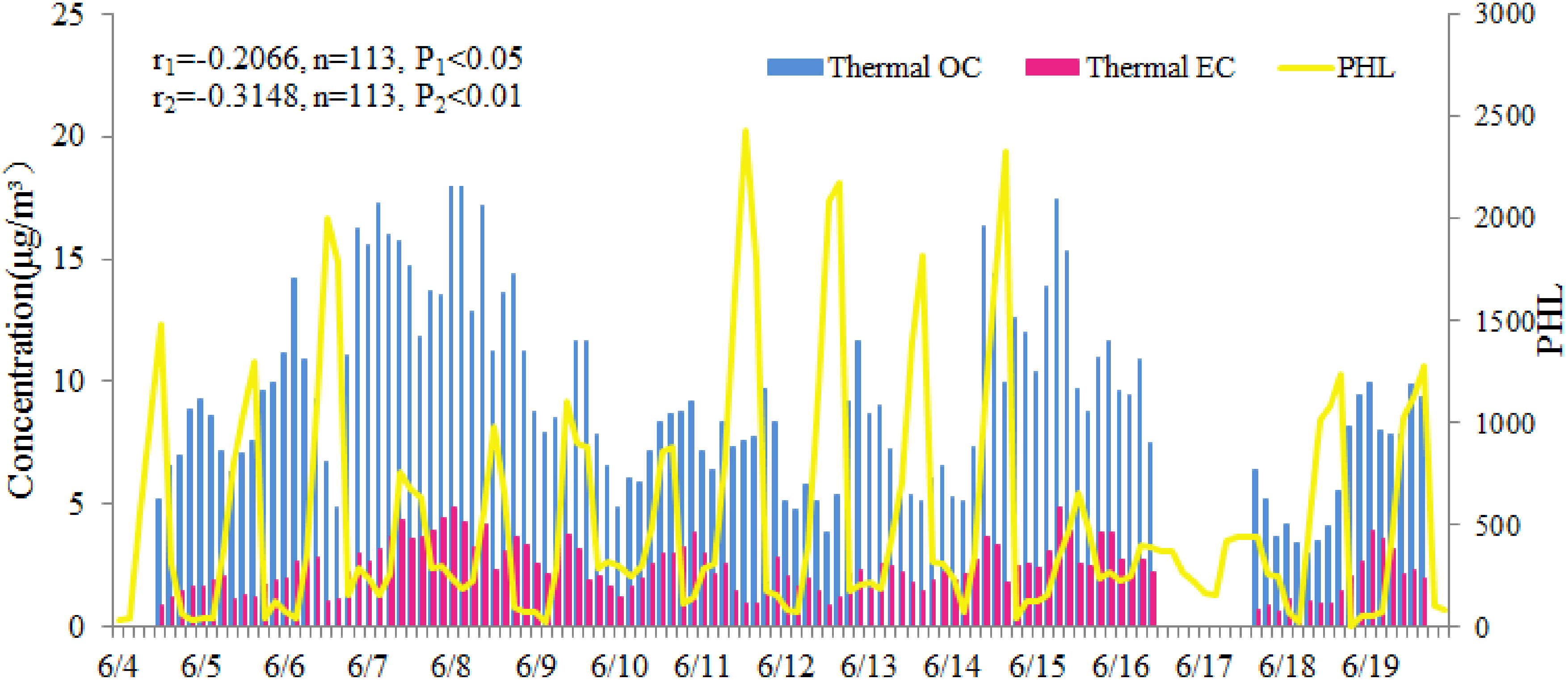


Figure 15. Correlation between boundary layer height and thermal OCEC(658nm) at NUIST on June in 2015

➢ Diurnal variation of OC, EC, OC/EC and dEC

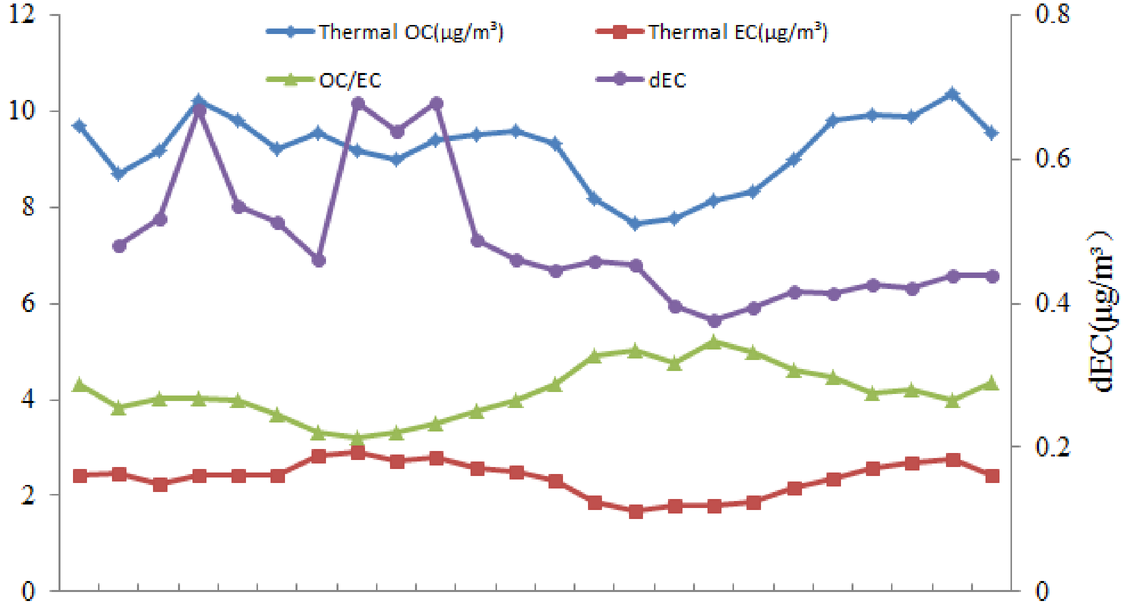


Figure 16. Averaged diurnal variation of OC, EC, OC/EC(658nm) and dEC

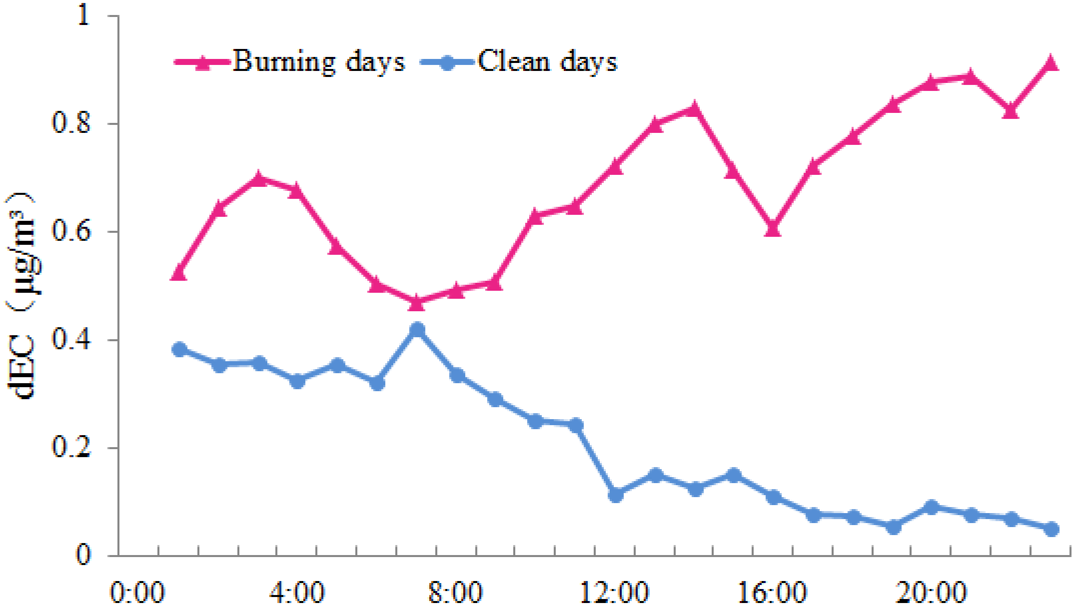


Figure 17. Diurnal variation of dEC on burning days and clean days

Conclusion

- dEC strongly indicated the biomass burning implication and revealed the variation of Brown Carbon.
- Fossil fuel combustion and vehicle emission made great contributions to the EC concentrations at NUIST.
- The boundary layer height had great influence on the diffusion of particle matter. The correlation between the boundary layer height and the concentrations of OC and EC were significantly negative.

➢ Future work

- Using the meteorological measurements to do further source apportionment of OC and EC.
- Do quantitative analysis on the characterization of OC, EC, POC and SOC.
- Get the data of the whole summer to do more research.

Thank you