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Study on the characteristics of carbonaceous aerosols in the industrial area in North Nanjing

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YN-center Video Conference

2017.04.07

Outline

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- Experiment description
- Results and discussion
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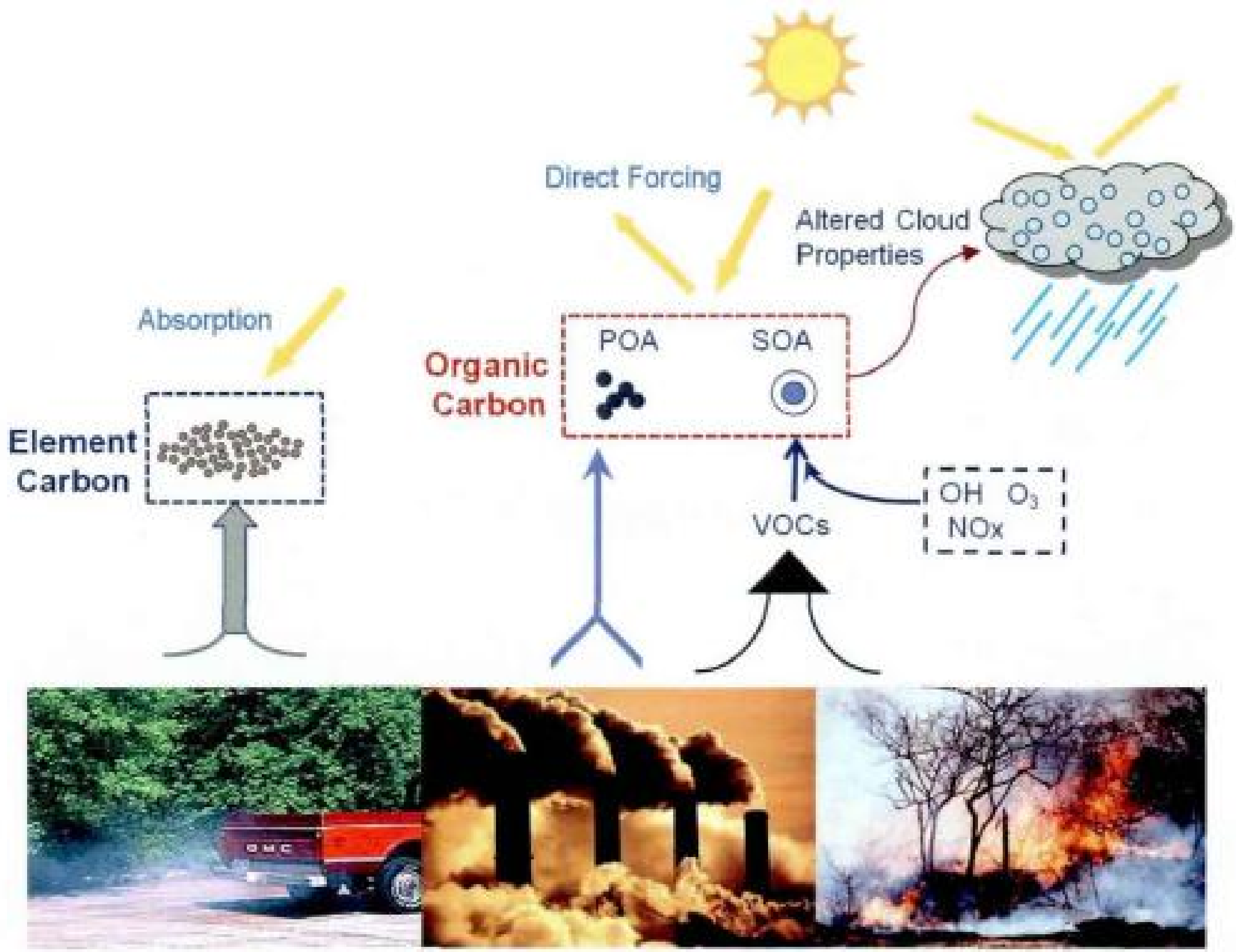
Introduction

- Carbonaceous species, as significant chemical components of $PM_{2.5}$, have been found to be widely associated with global radiative transfer, health problems and visibility deterioration.

- Carbonaceous aerosol is usually divided into organic carbon (OC) and elemental carbon (EC) fractions. EC is mainly emitted from fossil fuel and biomass combustion, and is of special interest because it could cause positive radiative forcing and was found to be the second most important factor of global warming behind CO_2.

- OC originates both from direct emissions as primary organic carbon (POC) and gas-to-particle conversion as secondary organic carbon (SOC) and can cause negative forcing due to its scattering of sunlight.



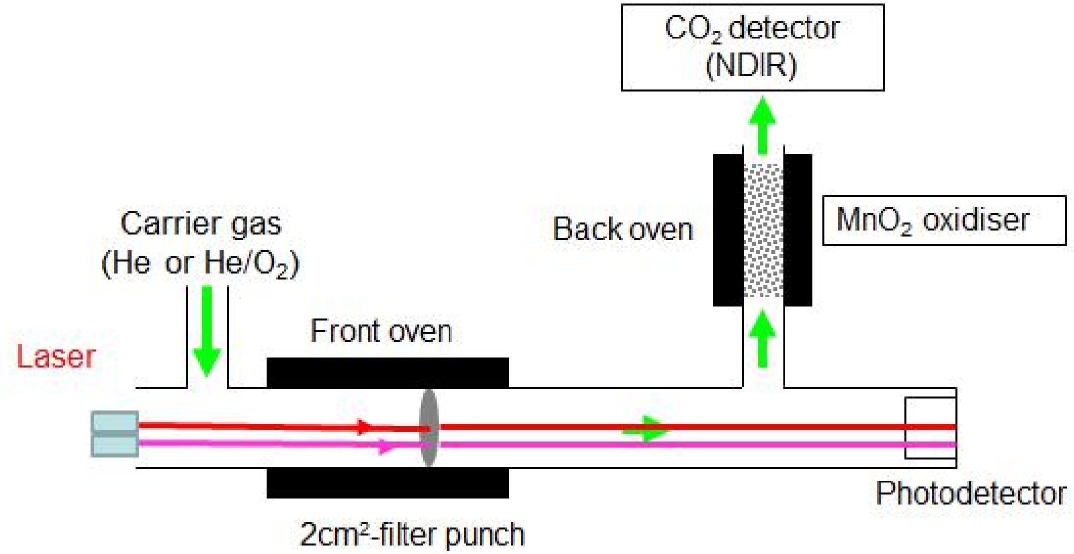
Direct Forcing
Altered Cloud
Properties
Absorption
Organic
Carbon
POA
SOA
Element
Carbon
OH O3
NOx
VOCs

（Wang Z，2011）

➢ Experiment description

Online

- Online Data: $PM_{2.5}$, OC, EC , BrC
- Observation time: 2015.6-2016.8
- Observation site: Nanjing University of Information Science and Technology (NUIST)



Drawn by Prof. Zhang Yanlin

Offline

Sampling site:

(The photo was taken by Tang Tianran)

Sampling time: 2015.10.6-2015.11.5
Samples: $PM_{2.5}$
Sampling frequency: 12 hours
Chemical analysis: OC, EC, Levoglucosan (LG)

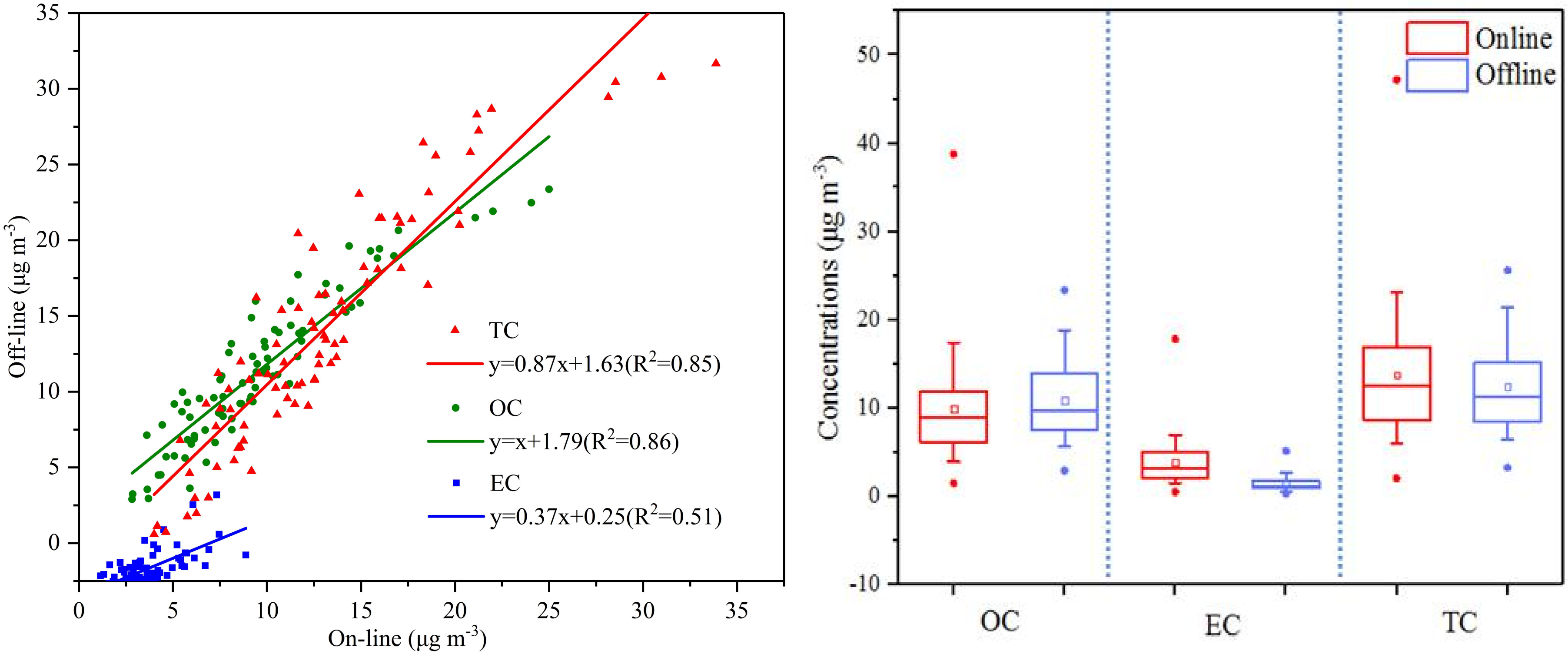


Fig.1. Comparison of OC and EC concentrations measured by on-line sampling and off-line sampling.

➢ Results and discussion

OC and EC concentrations

Table 1. Statistical summary on the $PM_{2.5}$, OC and EC concentrations.

N=5920	Mean	Standard Deviation	Media	Min	Max
$PM_{2.5}$	72.8	48.1	60.6	1.6	458.1
PM_{10}	108.9	65.9	94.0	2.4	485.7
OC	8.4	5.7	6.9	0.1	74.0
EC	3.2	2.1	2.6	0.0	17.8
OC/EC	2.9	1.5	2.6	0.3	16.5
$OC/PM_{2.5}$(%)	12.7	5.9	11.5	0.5	69.5
$EC/PM_{2.5}$(%)	4.8	2.4	4.3	0.0	35.1
$TC/PM_{2.5}$(%)	17.4	7.3	16.1	0.7	74.7
OC/PM_{10}(%)	8.3	3.9	7.6	0.3	55.0
EC/PM_{10}(%)	3.1	1.5	2.8	0.0	24.6
TC/PM_{10}(%)	11.5	4.8	10.6	0.4	58.7

Table 2. Comparisons of the concentrations of OC and EC between different cities.

Site	Sampling period	OC	EC	OC/EC	Method
Beijing	Mar 2013-Feb 2014	14.0	4.1	3.4	TOT
Taiyuan	Aug 2009-Apr 2010	37.4	19.6	1.9	TOR
Xian	Jan-Oct 2010	18.6	6.7	2.9	TOR
Shanghai	Oct 2005-Jul 2006	14.7	2.8	5.0	TOT
chengdu	May 2012-Apr 2013	19.0	4.6	4.3	TOT
Chongqing	May 2012-Apr 2013	15.2	4.0	3.8	TOT
Nanjing	Annual 2014	5.7	3.2	1.8	TOT
Nanjing	Jun 2007-May 2008	15.7	10.4	2.4	TOR
Nanjing	May 2013-Jul 2013	13.0	2.6	5.2	TOR
Xiamen	Apr 2009-Jan 2010	15.8	2.7	5.8	TOT
Guangzhou	Mar 2012–Feb 2013	6.1	0.8		TOT
Hongkong	Aug 2011-May 2012	3.0	1.9		TOT
Sanya	Jan –Feb 2012	3.4	1.3	2.7	TOR
Sanya	Jun-Jul 2013	3.2	0.9	3.6	TOR
Mount Tai	Mar-Apr 2007	6.1	1.8	5.0	TOT
Mount Tai	Jun-Jul 2007	5.1	1.0	6.2	TOT
Mount Heng	Mar-May 2009	3.0	0.5	5.2	TOT
Mexico	Mar 2006	6.4	2.1	4.5	TOT
Delhi	Nov 2010-Feb 2011	54.1	10.4	5.2	TOT
Philadelphia	Jul 2002-Aug 2002	4.8	0.4	18.7	TOT
Rochester	Jun 2002	9.2	0.3	23.6	TOT
Italy	Nov 2011–Mar 2012	9.9	1.3	6.8	TOT
Italy	Oct 2012–Mar 2013	6.9	2.2	3.3	TOT
Spain	Dec 2011	3.6	1.1	4.7	TOT
Nanjing(This study)	Jun 2015-Aug 2016	8.4	3.2	2.9	TOT

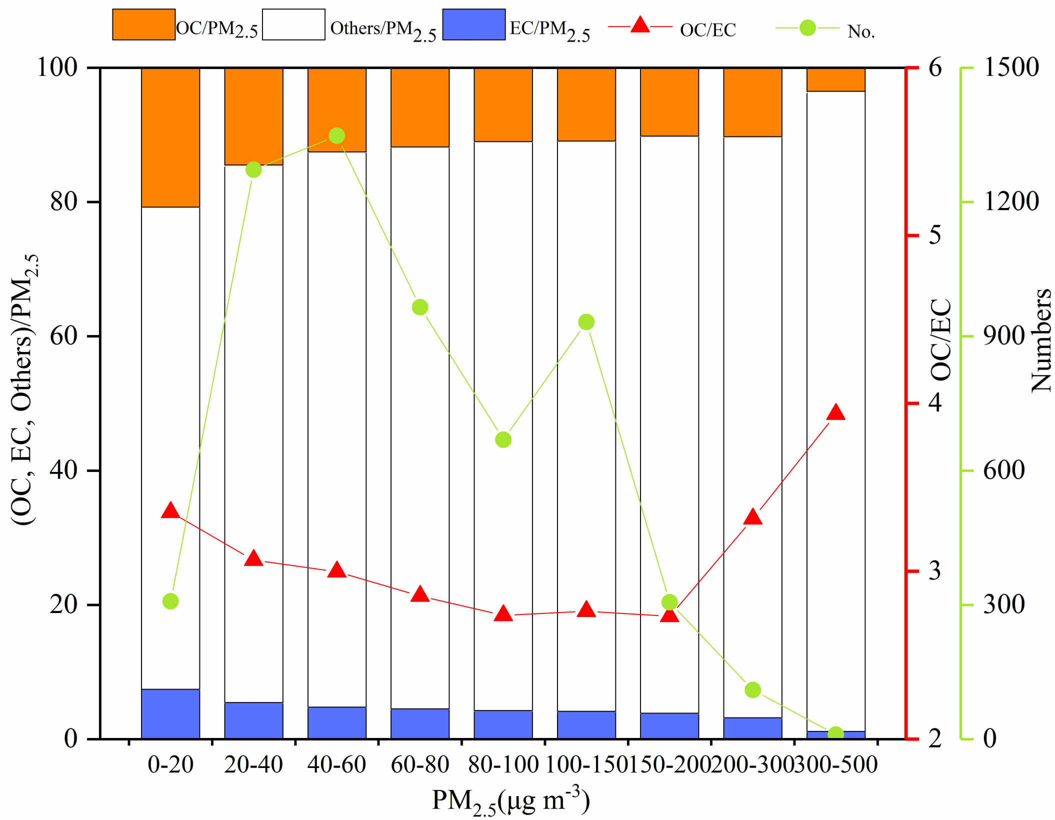


Fig.2. The carbonaceous species fractions of $PM_{2.5}$ and OC/EC ratios at different $PM_{2.5}$ concentration intervals at NUIST from June 2015 to August 2016.

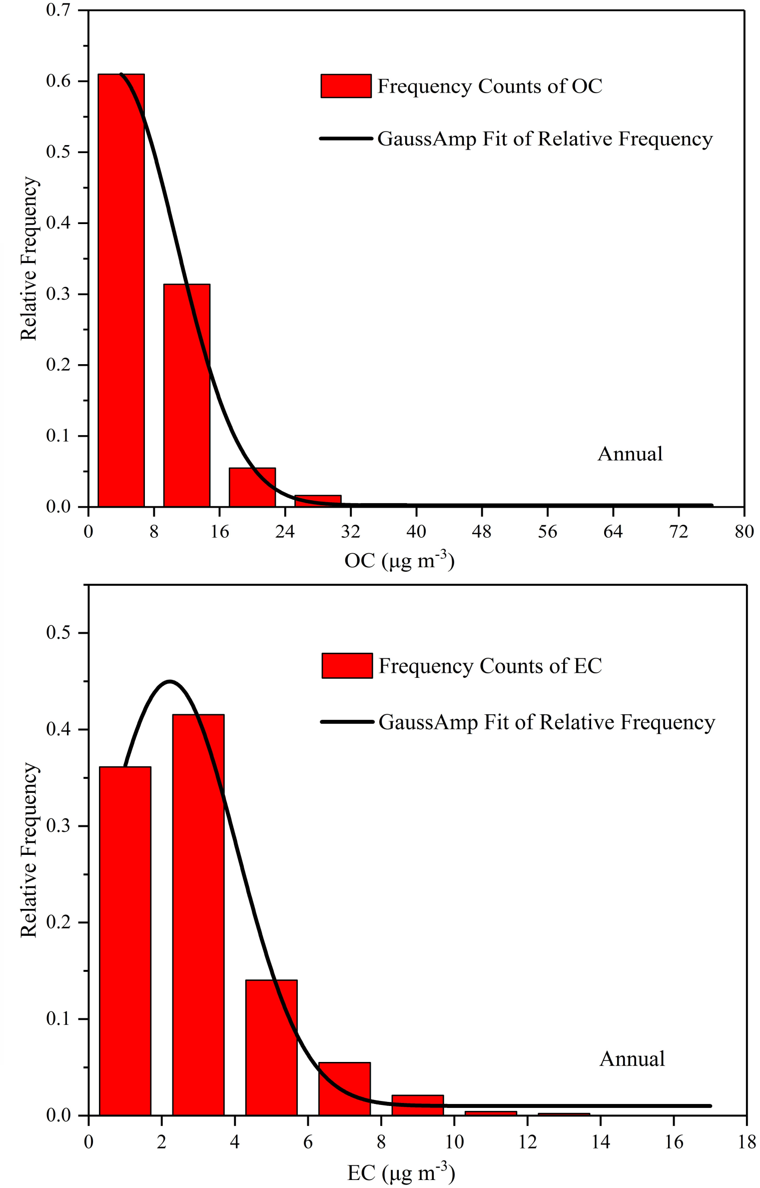


Fig.3. Probability distribution of OC and EC concentrations from June 2015 to August 2016.

Seasonal variation of OC and EC concentrations

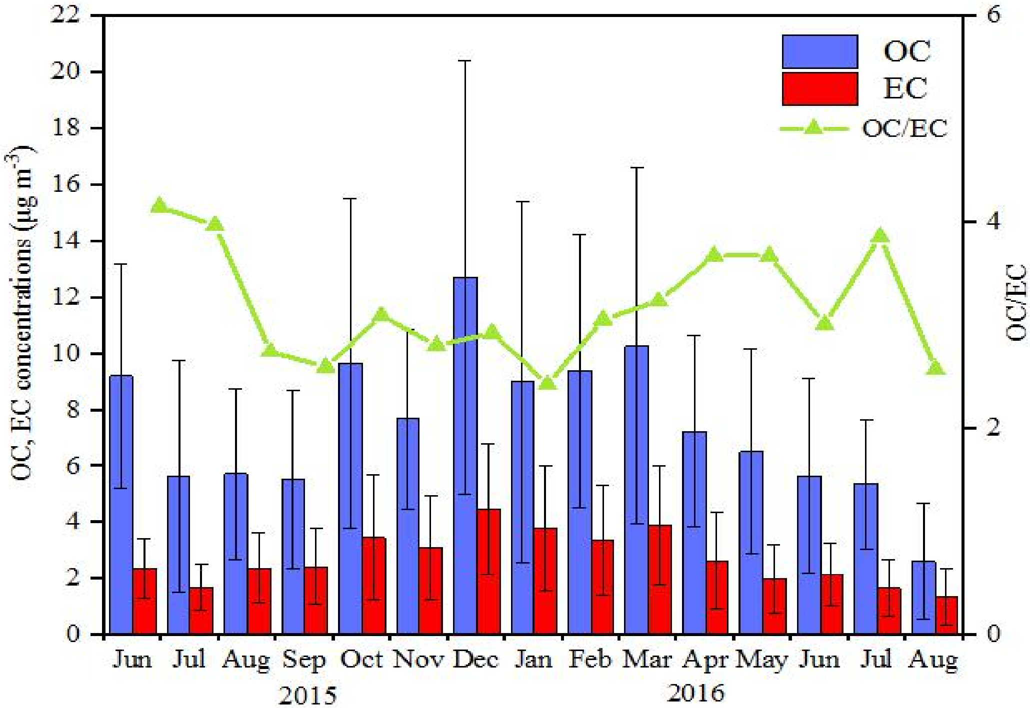


Fig.4. Monthly variations of OC and EC concentrations and OC/EC ratios at NUIST from June 2015 to August 2016. Error bars represent the standard deviation of OC and EC concentrations.

Table 3. The meteorological parameters (mean values) in different seasons.

	Pressure (hPa)	Relative Humidity(%)	Temperature (°C)	Wind Speed (m s^{-1})	Total Precipitation (mm)
Spring	1009.9	61.6	17.7	1.3	256.3
Summer	1000.7	74.7	25.3	0.9	586.0
Autumn	1014.6	69.6	17.8	0.9	218.5
Winter	1027.0	70.0	5.6	1.1	82.1

Diurnal variation of OC and EC concentrations

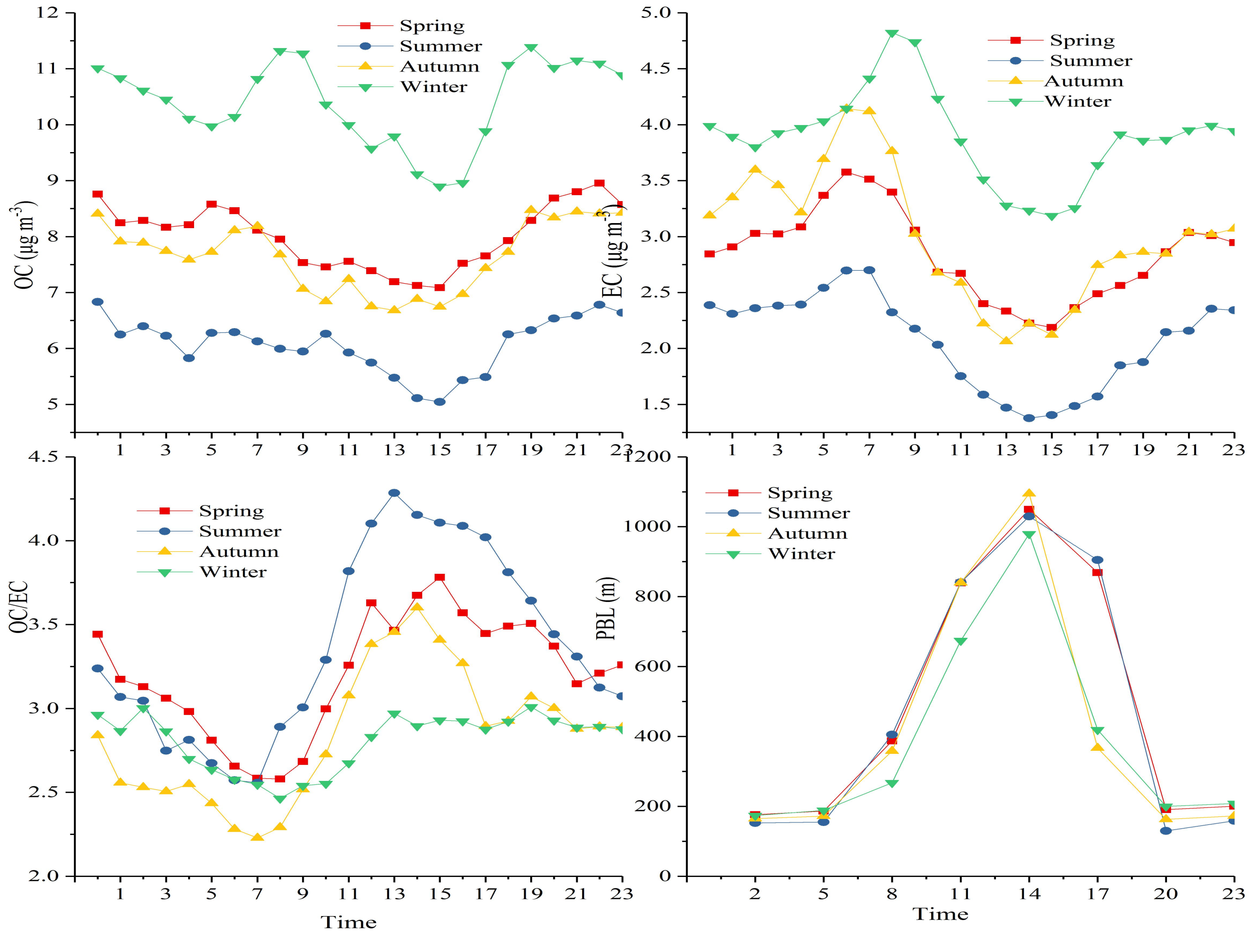


Fig.5. Diurnal variations in OC, EC, OC/EC and the boundary layer height in four seasons.

The relationship between OC and EC concentrations

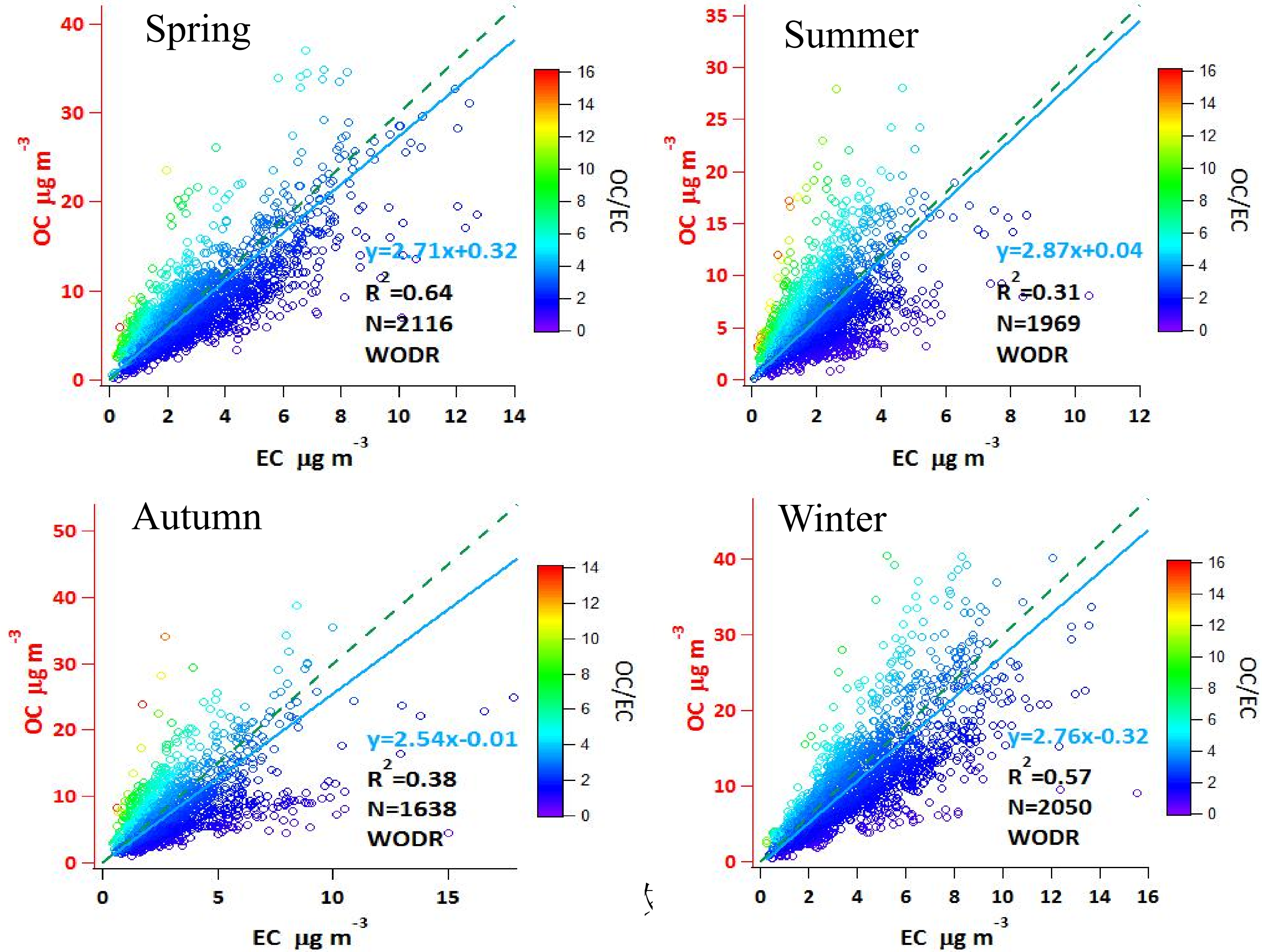


Fig.6. Correlation between OC and EC concentrations classified by OC/EC interval.

SOC estimation

EC-tracer method:

$$SOC = OC_{total} - OC_{pri} \qquad (1)$$

$$OC_{pri} = EC * (OC/EC)_{pri} \qquad (2)$$

OC_{total} and EC are available from ambient measurements.
$(OC/EC)_{pri}$ is the OC/EC ratios in freshly emitted combustion.

The minimum R squared (MRS) method:

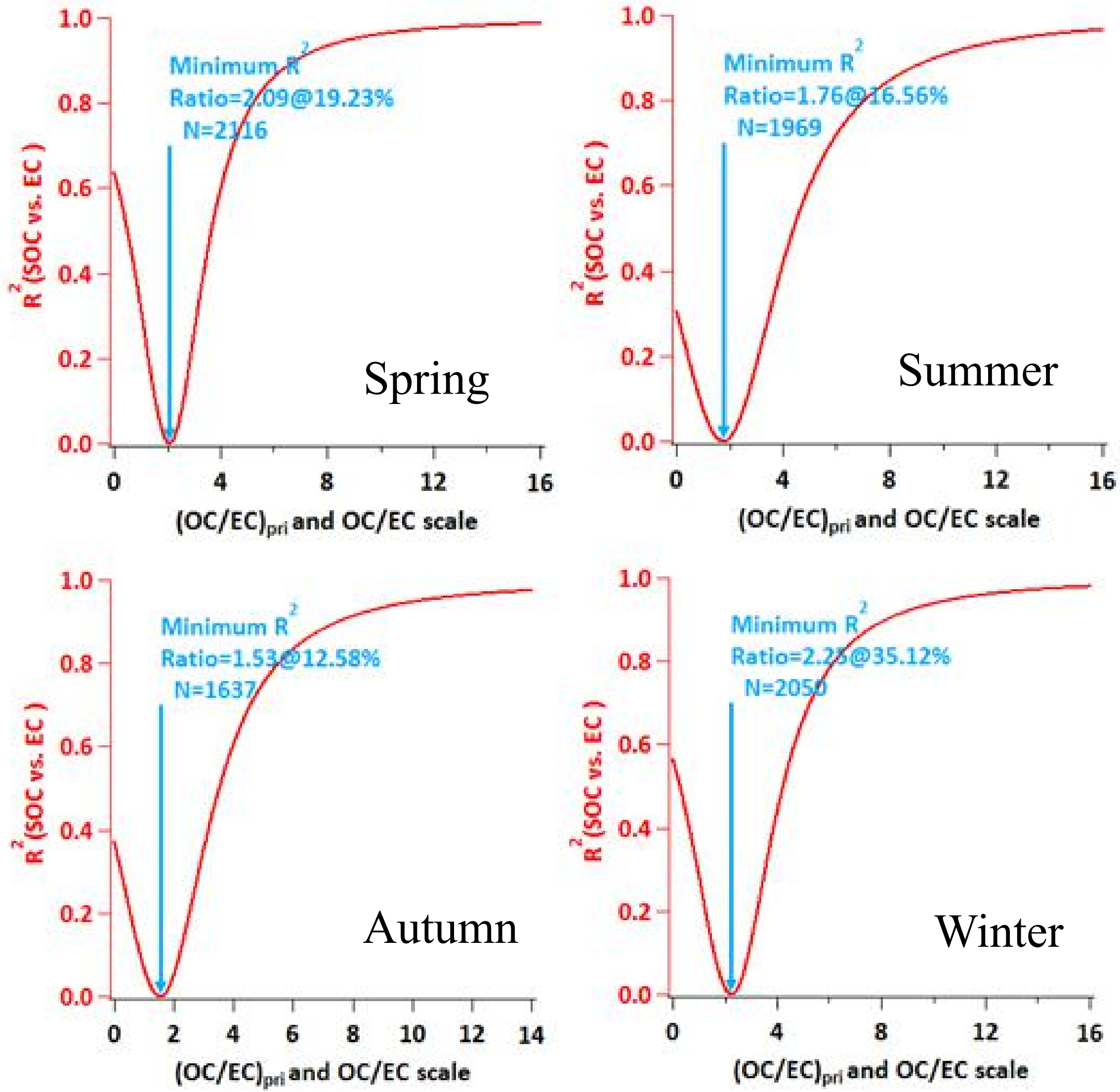


Fig.7. R^2 between SOC and EC as a function of assumed $(OC/EC)_{pri}$.

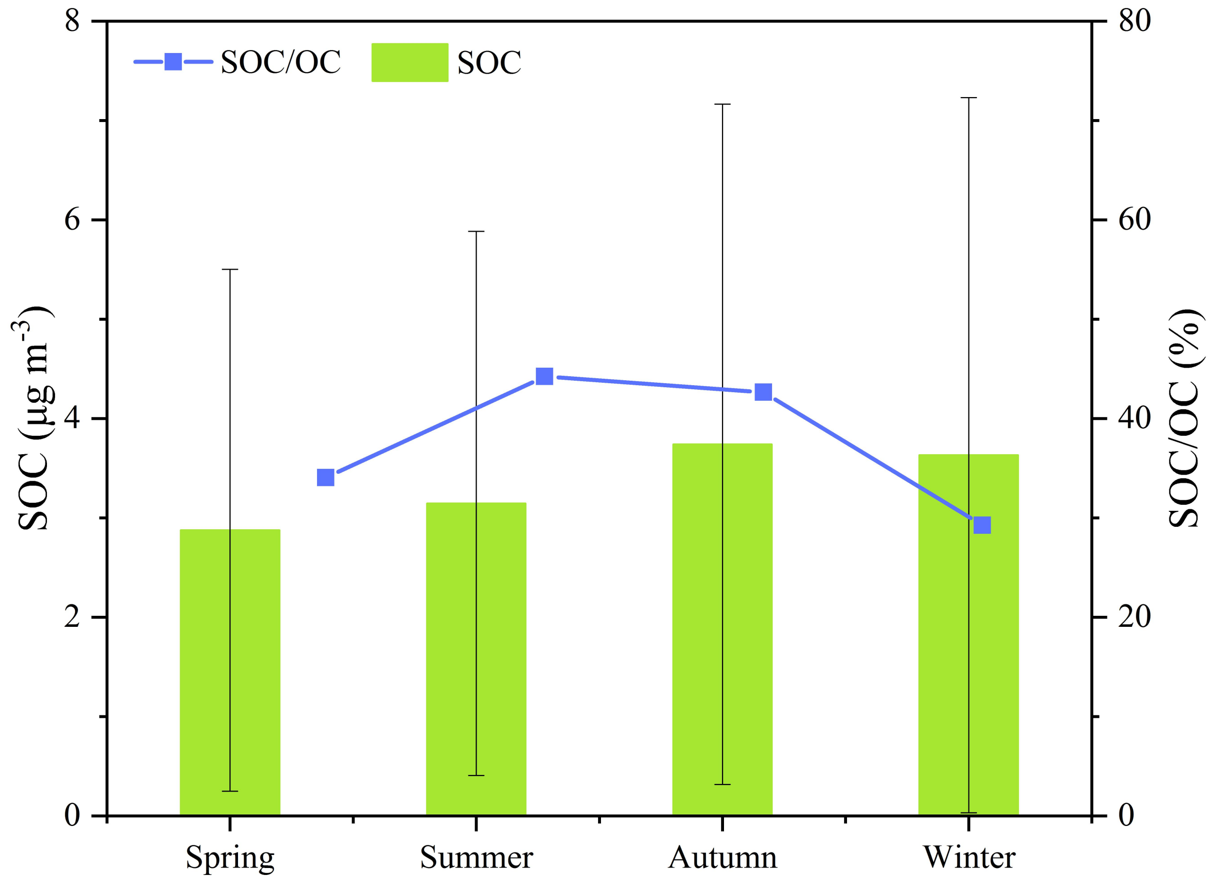


Fig.8. Seasonal SOC concentrations and SOC/OC ratios from June 2015 to August 2016. Error bars represent the standard deviation of SOC concentrations.

Air mass transport influence on OC and EC concentrations

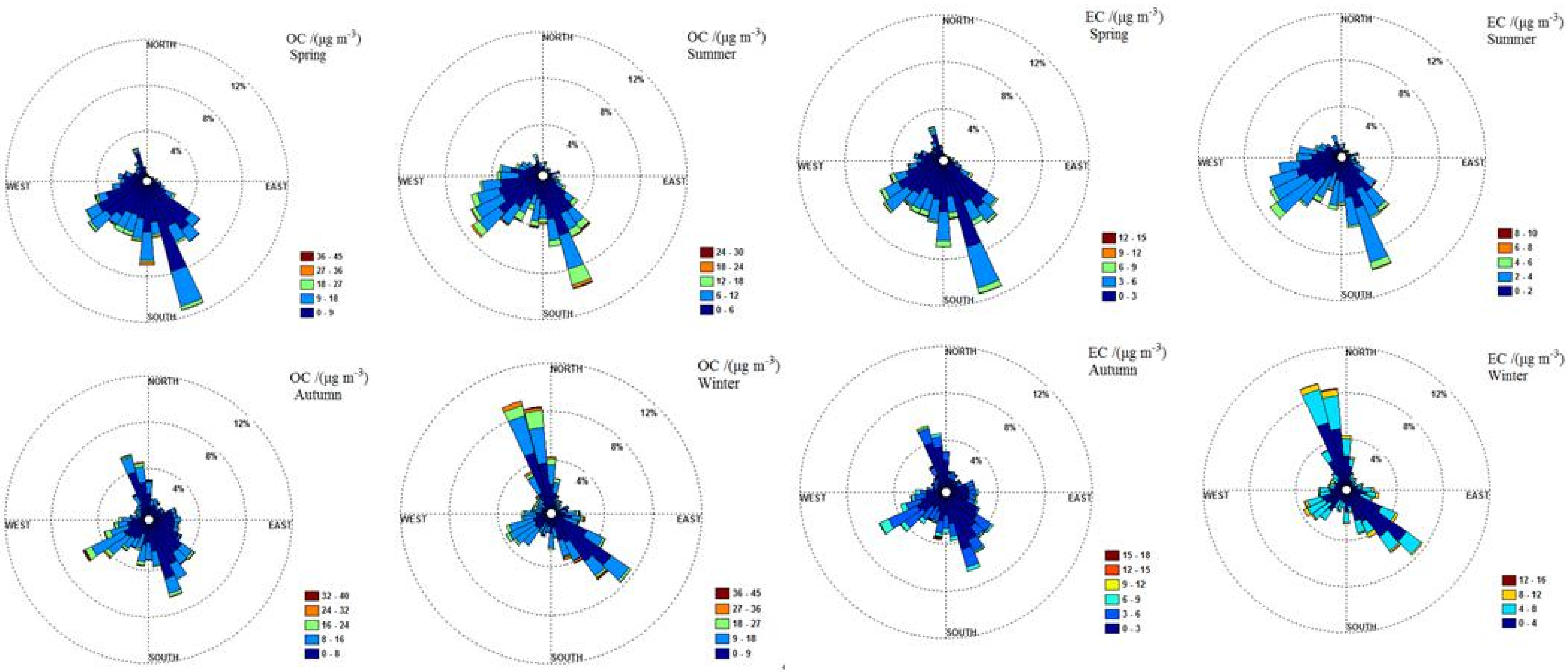


Fig.9. Wind rose of OC and EC in four seasons.

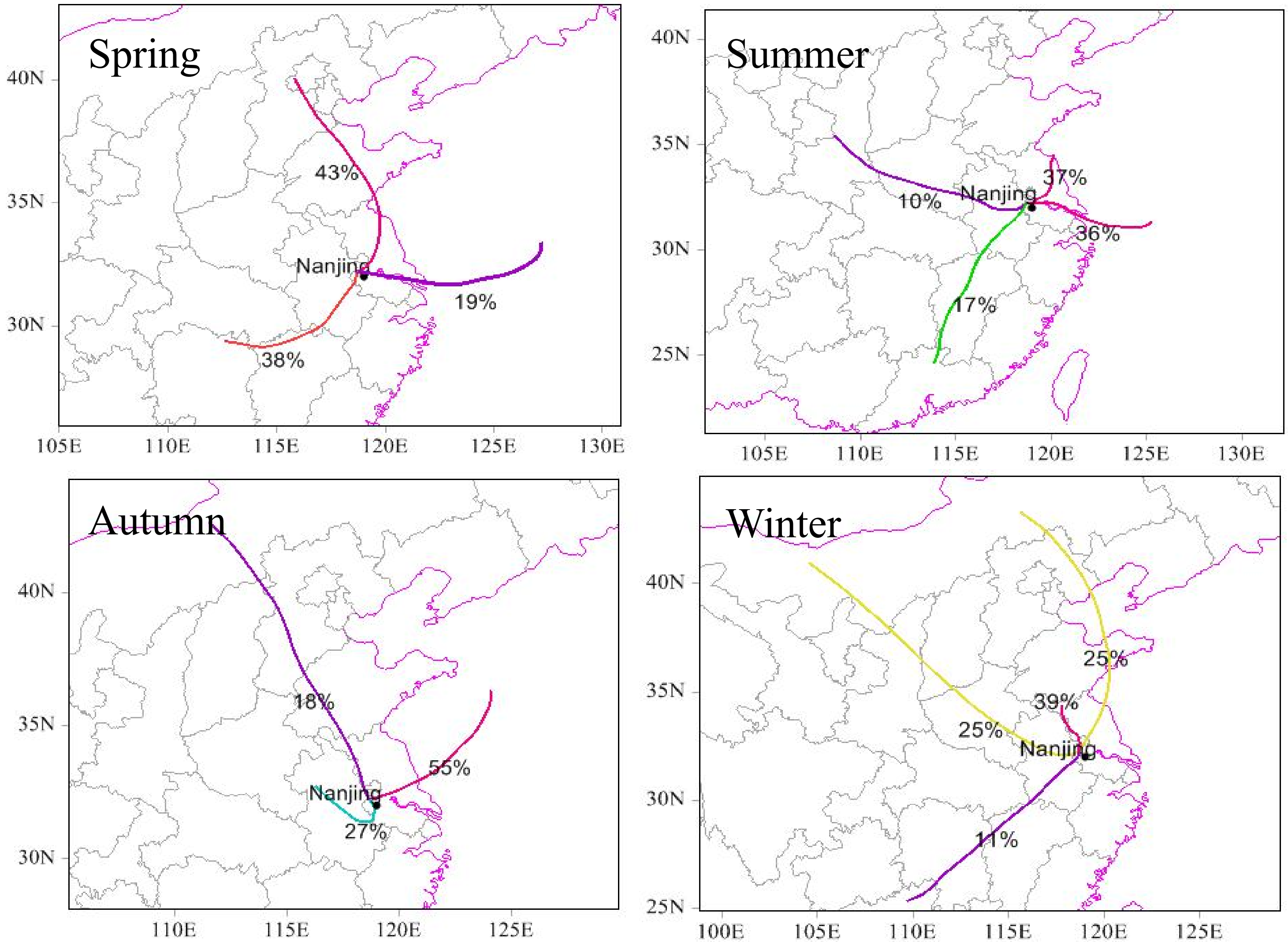


Fig.10. Cluster analysis of the 48 hours backward trajectories at 500m in NUIST in four seasons.

➢ Conclusion

- OC and EC concentrations remained at a middle level in North Nanjing compared with other sites in China.
- High (low) OC and EC concentrations were found in Winter (summer), indicating the significant impact of coal combustion in winter and wet scavenging of rain in summer. Similar diurnal cycles for OC and EC concentrations were found in four seasons with high at night and low in daytime, strongly effected by the boundary layers.
- The high SOC/OC in summer indicated the strong contribution of SOC due to the higher temperature, stronger solar radiation and more volatile organic compounds emissions in summer. The low SOC/OC in winter and spring indicated the relatively single sources of carbonaceous aerosols
- Highly polluted air masses in winter and spring were mainly from North China in winter and spring and from inland areas in autumn. Clean air masses in summer were coming from ocean areas.

➢ Future work

- Do further analysis on the data to estimate the characteristics of SOC and add the trace gases data analysis.

- Do further chemical and physical analysis, for instance, Positive Matrix Factorization (PMF), a source-receptor model analysis are needed to identify more detailed emission source information.

Thank you