Observation Studies on Atmospheric Pollutants in Hangzhou

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Outline

Background

In pace with fast development of urbanization and modernization, the rapid growth of urban people, the irrational pattern in the industry and the irrational energy structure make the air pollution becomes increasingly serious.

A series of air pollution episodes occurred one after anther in many cities in China since 2013 which drew great attention of people and scientists.

Some existing studies on atmospheric pollutants in Hangzhou are not very thorough and not very comprehensive enough, so it is very necessary to take long-term observation and studies on atmospheric pollutants in Hangzhou.

Site description

The monitoring station is located in a flat land where there are few tall buildings and local source.

Data screening

a、 The effective hourly mean value is the mathematic average of at least 75% of effective values of one hour.

b、 The effective daily mean value is the mathematic average of at least 18 effective hourly mean values of one day.

c、 The effective monthly mean value is the mathematic average of at least 21 effective daily mean values of one month.

d、 The effective annual mean value is the mathematic average of total of 12 effective monthly mean values of one year.

Results

Table 1 Exceeding standard rates of some atmospheric pollutants in 2014

Items	Average time	Exceeding standard times	Total	Exceeding standard rates/%
O_3	Daily peak 8 hours average	47	365	12.9
	Hourly average	124	8534	1.4
NO_2	Annual average	1	1	100
	Daily average	19	365	5.2
	Hourly average	0	8702	0
SO_2	Annual average	0	1	0
	Daily average	0	365	0
	Hourly average	0	8688	0
CO	Daily average	0	365	0
	Hourly average	0	8705	0
$PM_{2.5}$	Annual average	0	1	0
	Daily average	112	365	30.7
PM_{10}	Annual average	0	1	0
	Daily average	39	365	10.7

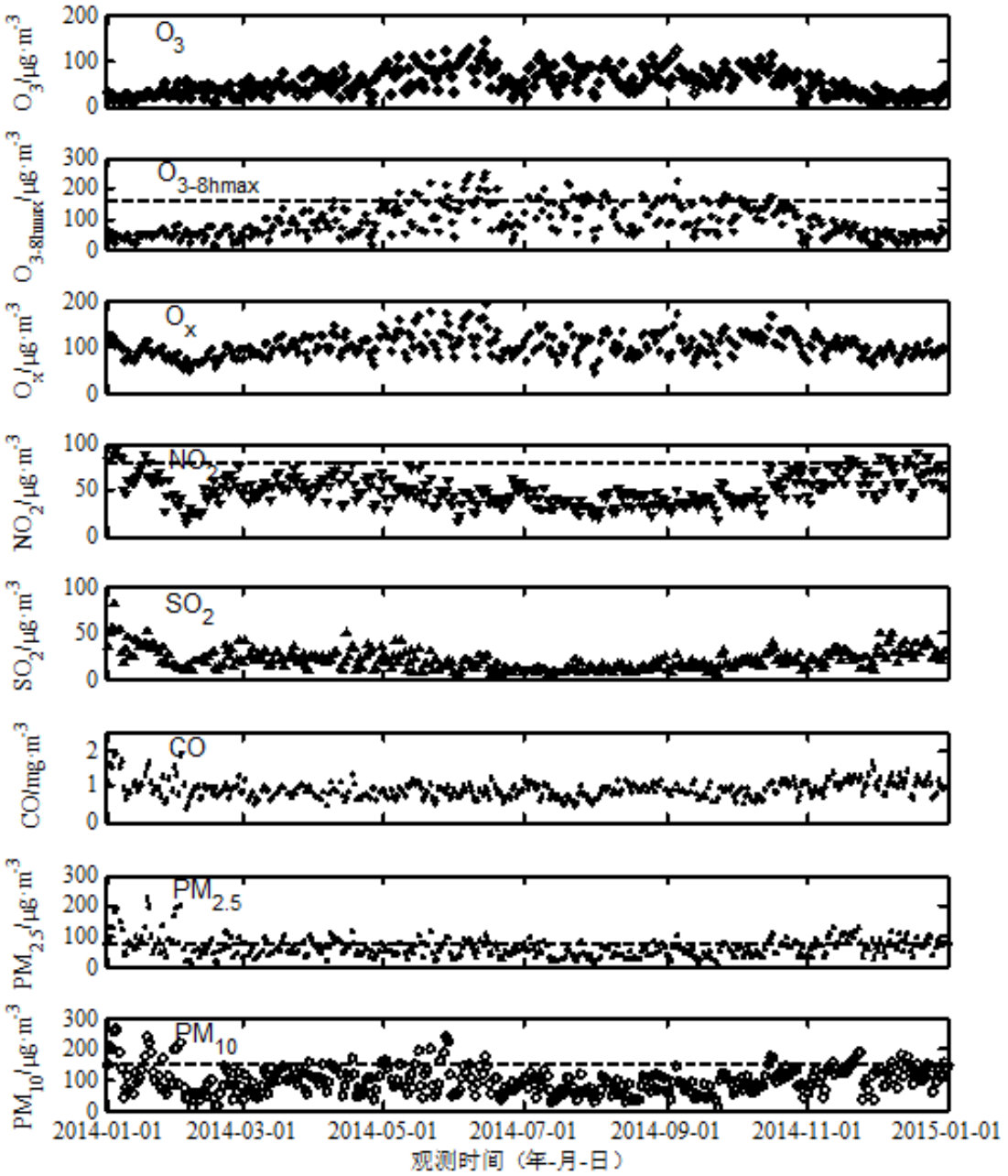

Fig. 1 Concentration variation of O_3, O_x, $O_{3\text{-}8hmax}$, NO_2, SO_2, CO, $PM_{2.5}$ and PM_{10} in 2014

Table 2 Seasonal concentrations of some atmospheric pollutants in 2014/μg·m^{-3}

Items	Spring	Summer	Autumn	Winter	Annual mean
O_3	56.6±44.3	70.9±56.3	58.6±47.9	28.1±21.0	53.7±47.1
O_x	108.7±37.5	109.1±51.4	109.5±40.7	86.8±22.0	103.6±40.6
NO_2	52.2±20.4	38.4±15.3	51.3±22.1	59.1±24.5	50.2±22.1
SO_2	22.2±12.9	11.9±7.0	19.3±10.3	29.6±16.7	20.7±13.8
CO(mg m^{-3})	0.85±0.24	0.83±0.24	0.95±0.28	1.05±0.40	0.92±0.31
$PM_{2.5}$	62.3±30.5	50.9±26.5	63.7±33.2	82.8±52.3	64.8±38.6
PM_{10}	106.1±55.0	79.4±42.1	96.1±46.4	113.7±66.7	98.8±54.8

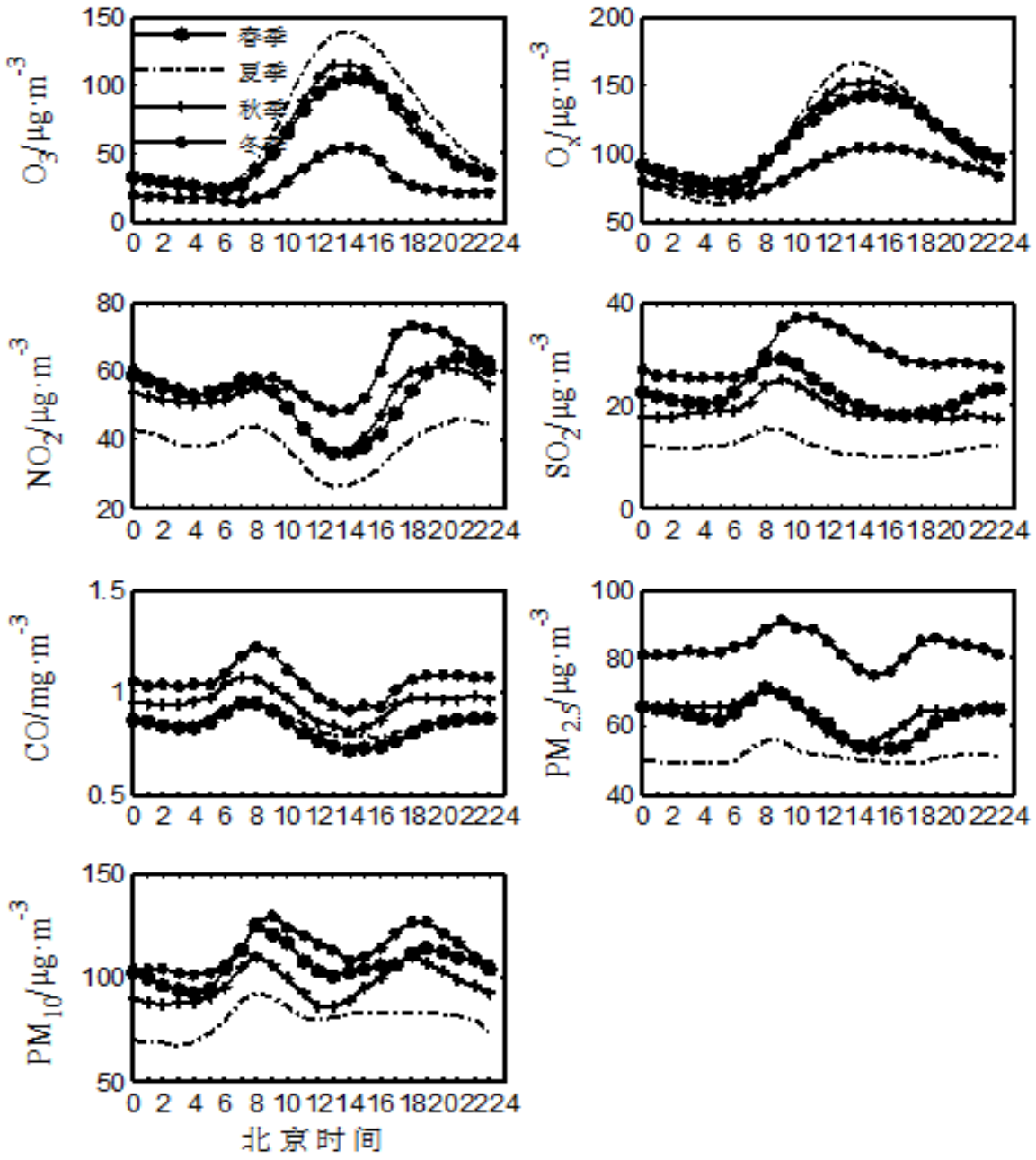

Fig. 2 Daily variation of O_3, O_x, NO_2, SO_2, CO, $PM_{2.5}$ and PM_{10} during different seasons in 2014

Table 3 Weekly concentrations of NO_2 and O_3 in 2014/μg·m^{-3}

	Days of week							Extremums	
	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Maximum	Maximum
Daily average									
NO_2	47.7	49.7	51.4	53.3	52.0	50.5	47.6	47.6(Sun)	53.3(Thurs)
O_3	55.6	52.5	53.3	56.1	55.6	51.6	51.2	51.2(Sun)	56.1(Thurs)
Daily peak									
NO_2	70.4	73.8	77.0	81.3	77.3	73.4	68.5	68.5(Sun)	81.3(Thurs)
O_3	110.8	104.9	114.0	121.2	114.2	108.2	104.2	104.2(Sun)	121.2(Thurs)

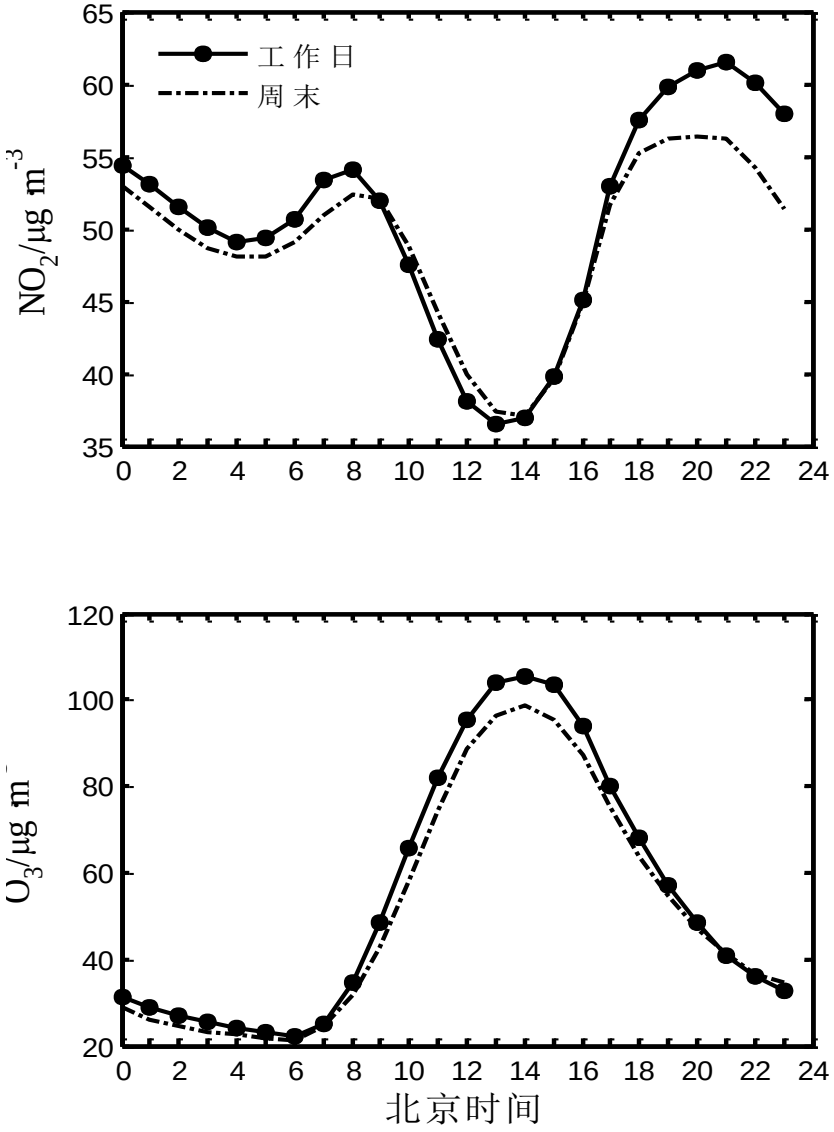

Fig. 3 Daily variation of NO_2 and O_3 in weekdays and on weekends in 2014

Table 4 Exceeding standard rates of some atmospheric pollutants during winter from 2012 to 2014

Items	Average time	Exceeding standard rates/%		
		2012	2013	2014
NO_2	Daily average	22.0	28.6	17.6
	Hourly average	0	0	0
	Seasonal average /μg·m^{-3}	62.19	65.26	59.62
SO_2	Daily average	0	0	0
	Hourly average	0	0	0
	Seasonal average /μg·m^{-3}	37.83	34.6	25.02
CO	Daily average	0	0	0
	Hourly average	0	0	0
	Seasonal average /μg·m^{-3}	1.37	1.26	1.12
$PM_{2.5}$	Daily average	54.9	59.3	52.7
	Seasonal average /μg·m^{-3}	89.19	106.62	79.43
PM_{10}	Daily average	22.0	36.3	20.9
	Seasonal average /μg·m^{-3}	110.08	134.62	112.5

Increase first and then decrease

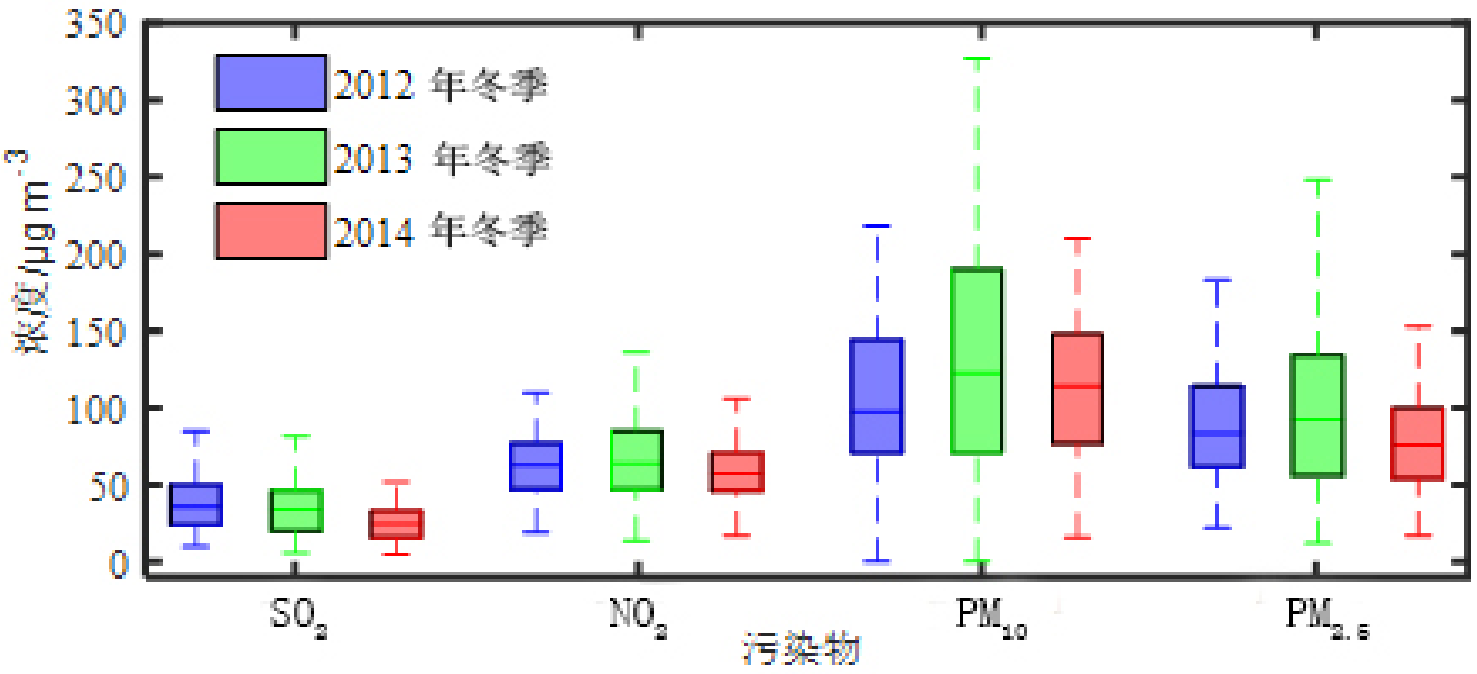

Fig. 4 Distribution characteristics of SO_2, NO_2, PM_{10} and $PM_{2.5}$ during winter from 2012 to 2014

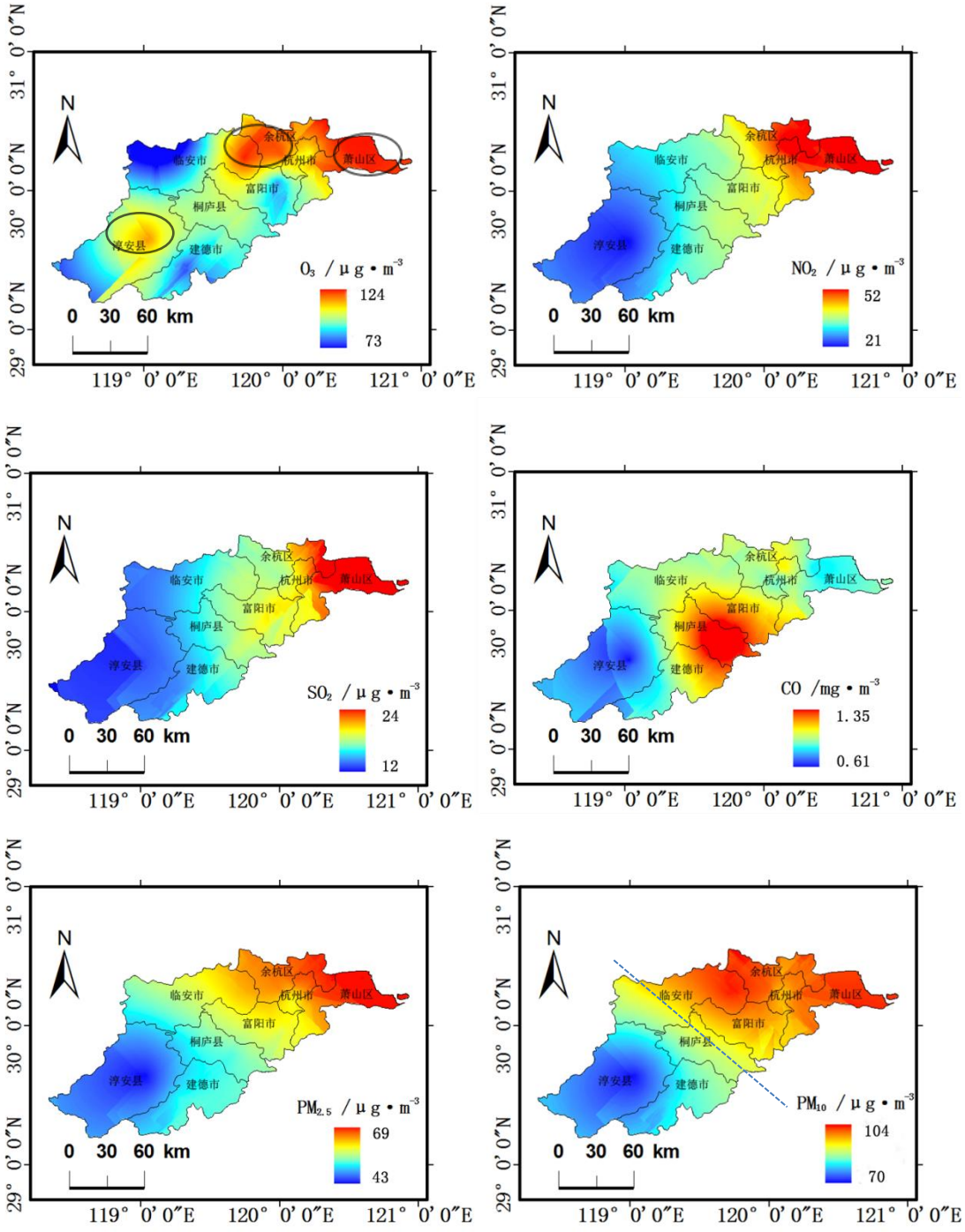

Fig. 5 Regional distribution of some atmospheric pollutants in 2014

Table 5 Correlation coefficients between pollutants and meteorological parameters based on hourly mean data during different seasons in 2014

Seasons	meteorological elements	NO_2	O_3	SO_2	CO	$PM_{2.5}$	PM_{10}
Spring	air temperature	-0.20**	0.59**	-0.10**	0.03	0.07**	0.33**
	wind speed	-0.44**	0.36**	-0.15**	-0.24**	-0.20**	-0.11**
	relative humidity	0.17**	-0.68**	-0.23**	0.32**	0.06*	-0.26**
Summer	air temperature	-0.37**	0.65**	0.06*	-0.24**	0.10**	0.21**
	wind speed	-0.44**	0.26**	-0.19**	-0.28**	-0.21**	-0.17**
	relative humidity	0.37**	-0.81**	-0.23**	-0.28**	-0.22**	-0.33**
Autumn	air temperature	-0.52**	0.60**	-0.23**	-0.39**	-0.29**	-0.21**
	wind speed	-0.46**	0.31**	-0.22**	-0.28**	-0.31**	-0.29**
	relative humidity	0.11**	-0.69**	-0.37**	0.27**	-0.03	-0.24**
Winter	air temperature	0.07*	0.41**	0.08**	0.04	0.19**	0.22**
	wind speed	-0.44**	0.40**	-0.11**	-0.24**	-0.21**	-0.15**
	relative humidity	-0.14**	-0.45**	-0.38**	0.15**	0.01	-0.23**

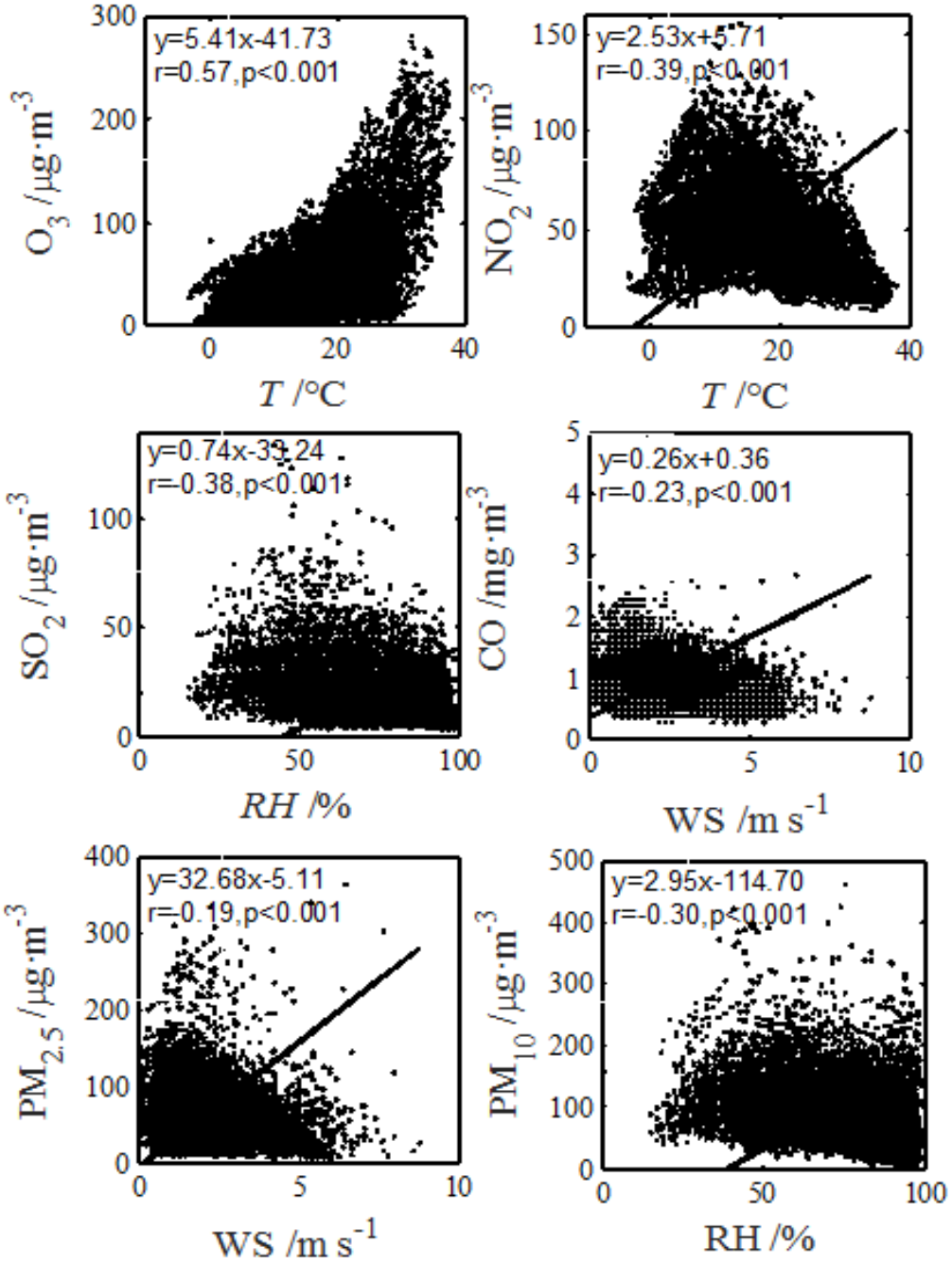

Fig.6 Correlation coefficients between pollutants and meteorological parameters in 2014

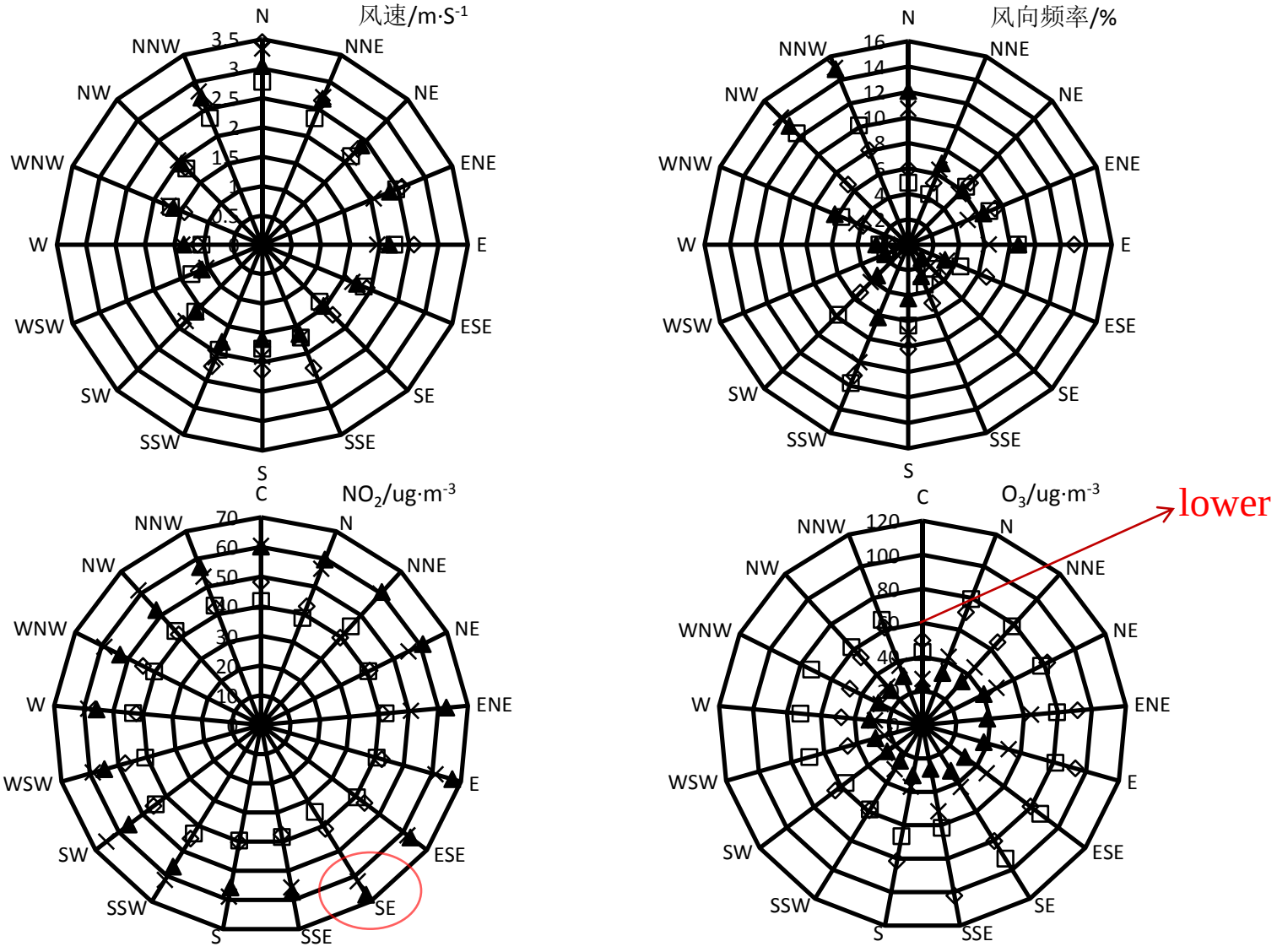

Fig.7 Relationship between the atmospheric pollutants and wind directions during different seasons in 2014

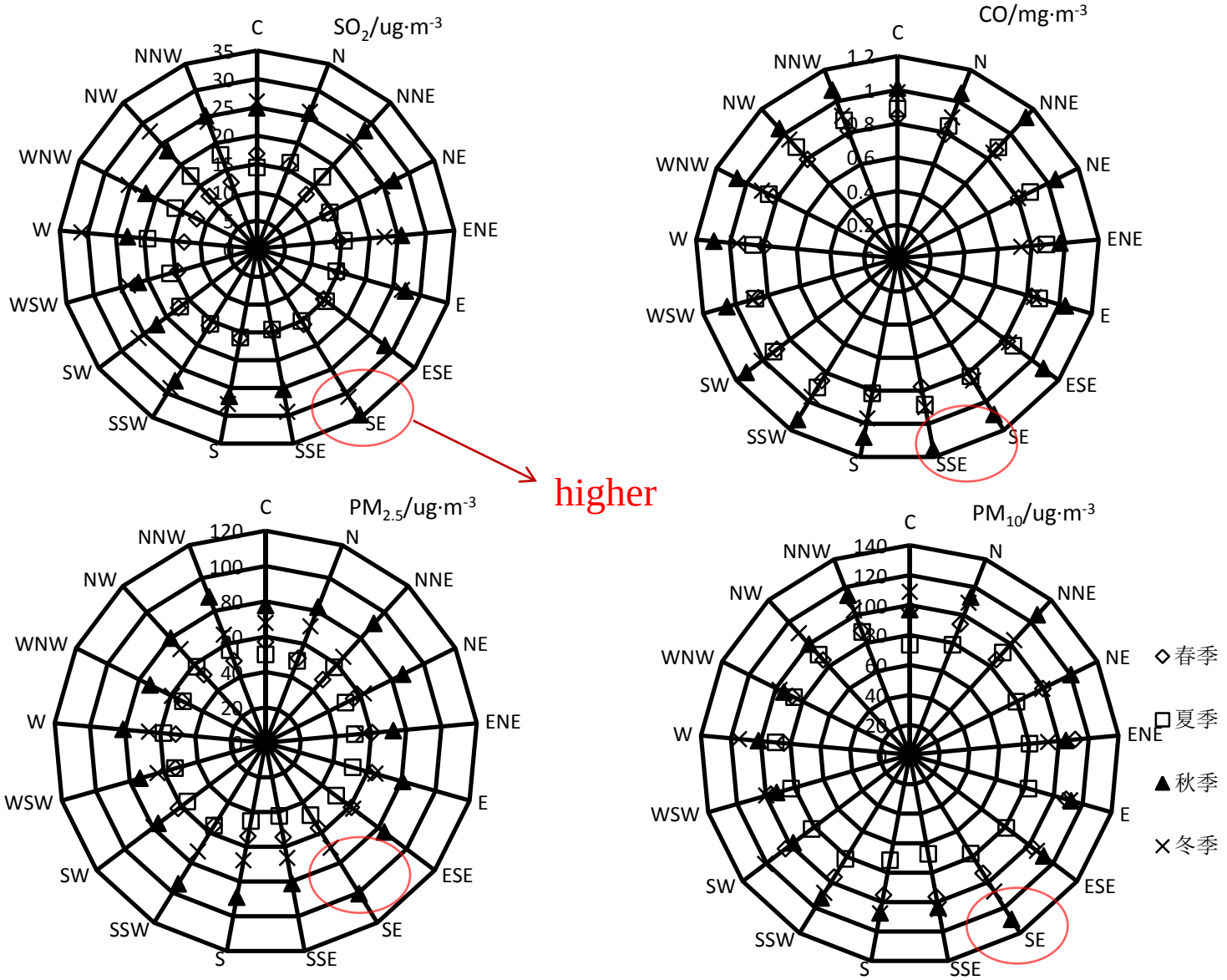

Fig.7 Relationship between the atmospheric pollutants and wind directions during different seasons in 2014

Conclusions

- Of the atmospheric pollutants, $PM_{2.5}$ was the most serious in the urban area of Hangzhou.
- The concentrations of the atmospheric pollutants displayed noticeable seasonal variation. The concentrations of O_3 from highest to lowest were in summer, autumn, spring and winter, while the others appeared higher in winter, lower in summer and changed smoothly in other seasons.
- The concentrations of the atmospheric pollutants showed different diurnal variation patterns. The curves of diurnal variations of O_3, Ox and SO_2 all showed single peak with different peak values time. The diurnal variations of NO_2, CO, $PM_{2.5}$ and PM_{10} were similar to the two peaks that appeared at the morning and evening rush hours.

- **The concentrations of NO_2 from 17:00 to 09:00 the next morning in weekdays were significantly higher than those on weekends. The situation from 09:00 to 14:00 was the opposite and the concentrations from 14:00 to 17:00 approximately equaled. But the concentrations of O_3 in weekdays were higher than those on weekends all the time.**

- **The exceeding standard rate of daily average concentrations and annual average concentrations of NO_2, $PM_{2.5}$ and PM_{10} of the winters of the last three years increased second year and then decreases from 2012 to 2014, while annual average concentrations of SO_2,and CO increased all the time.**

- **On the whole, the concentrations of the pollutants were decreased from the east to the west of Hangzhou gradually. There were 3 high-value regions of concentration of CO.**

- **Meteorological factors were an important factor for pollutant concentration distributions. The correlation analysis indicated that the concentration of O_3 was the most significant positively correlations with temperature and wind speed, while the most significant negatively correlations with relative humidity. The situation with NO_2 was the opposite. The concentrations of SO_2, CO, $PM_{2.5}$ and PM_{10} were the most significant negatively correlations with wind speed.**


Thank you !