Characteristics and driving factors of temporal variations in surface $PM_{2.5}$ over Suzhou and surrounding regions

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Outline

- Motivation and objectives
- Data and methodology
- Preliminary results
- Next steps

Motivation

- $PM_{2.5}$: solid particles or liquid droplets with diameter less than or equal to 2.5 micrometers in size.
- Impact on climate changes:

  - Direct radiative forcing: the scattering of solar radiation and the absorption/emission of terrestrial radiation

  - Indirect radiative forcing: mainly by effects of aerosols on cloud properties

- Impact on human health: one of major air pollutants
- Source: industrial, biomass combustion, wind-blown (mineral dust), and natural
- Components: elemental carbon, organic carbon, sulfate, nitrate, and so on.

Clear Skye versus haze day

$PM_{2.5}$ studies in Yangtze River Delta and China

- At present, study for the Chinese city PM2.5 is less, limited to a few big city, such as Nanjing, Beijing, mainly focus on the temporal and spatial variation. We lack research on the causes for the high concentration of events.

- $PM_{2.5}$ is becoming more and more serious in YRD; the transparency of atmosphere is getting worse; there is long-standing aerosol cloud.

Scientific questions and objectives

- What are the main features of temporal variations in surface $PM_{2.5}$ over Suzhou and surrounding regions?
- What kinds of weather systems cause high concentrations of $PM_{2.5}$ in this region?
- How do human activities influence temporal variations in surface $PM_{2.5}$ concentrations?

Observational data

Table.1 Summary of the data used in this study

	Suzhou	**Kunshan**	**Taicang**
2011	PM_{10} , $PM_{2.5}$, SO_2 , NO_x , O_3, Scattering coefficient, RH , Air temperature	PM_{10} , $PM_{2.5}$, SO_2 , NO_x , O_3 , Scattering coefficient	PM_{10} , $PM_{2.5}$
2012		PM_{10} , $PM_{2.5}$, SO_2 , NO_x , O_3 , Scattering coefficient , RH , Air temperature	

Preliminary results

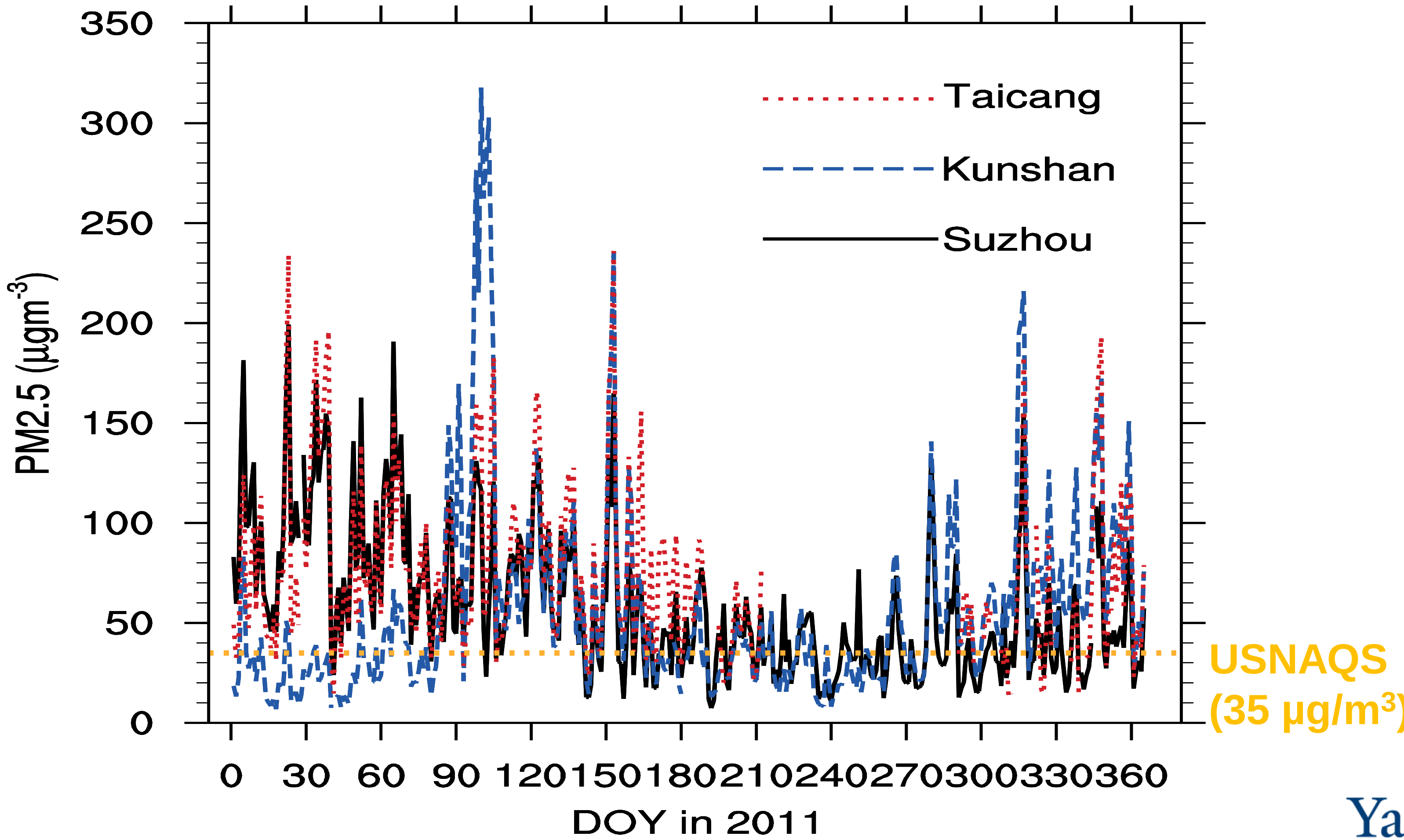

Fig.1 Time series of $PM_{2.5}$ concentrations in 2011

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USNAQS vs. China’s NAQS

Table.3 USNAQS vs. China CNAQS

	$PM_{2.5}$(μg/m^3)		PM_{10}(μg/m^3)		O_3 (ppb)	NO_2(ppb)		SO_2(ppb)	
US	Annual	24-hour	24-hour		8-hour	Annual	1-hour	3-hour	1-hour
	15	35	50		75	53	100	50	75
CHN	Annual	24-hour	Annual	24-hour	1-hour	Annual	1-hour	Annual	24-hour
	35	75	100	150	100	39	117	21	52.5

General features of $PM_{2.5}$

Table.2 Daily, monthly, yearly means of air pollutants in 2011

		$PM_{2.5}$(μg/m^3)	PM_{10}(μg/m^3)	O_3（ppb）	NO_x（ppb）	SO_2（ppb）
Kunshan	day	56.3	103.5	22.5	27.1	9.9
	month	56.7	103.6	22.5	27.2	9.9
	year	56.9	104.3	22.6	27.5	9.9
Suzhou	day	54.5	119.0	13.8	14.1	13.8
	month	58.4	106.7	23.8	39.8	14.6
	year	58.0	106.0	23.8	39.8	14.6
Taicang	day	72.5	126.9			
	month	72.8	128.6			
	year	75.8	130.8			

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Diurnal pattern of $PM_{2.5}$ (yearly mean)

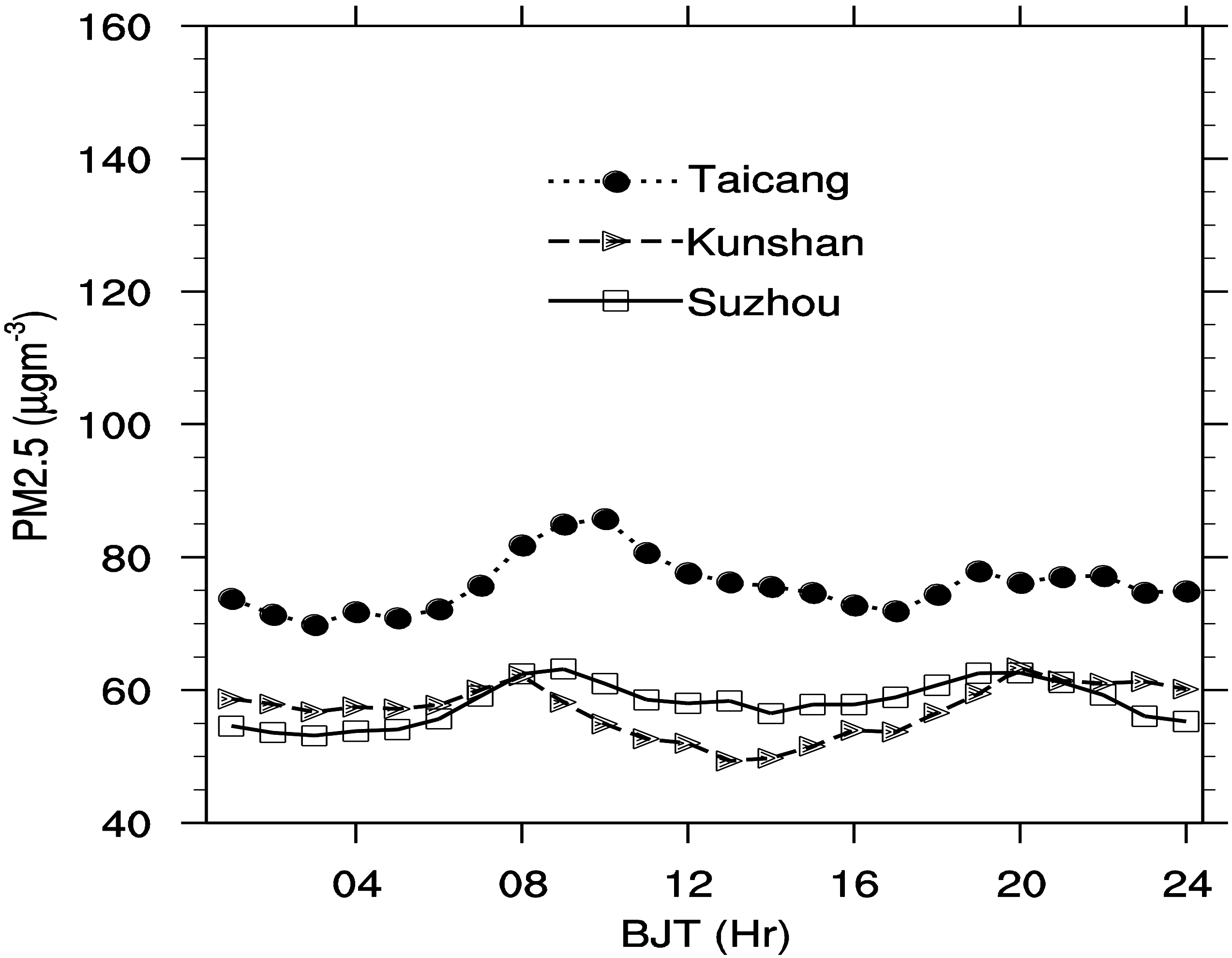

Fig.2 Daily variations in $PM_{2.5}$ in 2011

Diurnal pattern of PM_{10} (yearly mean)

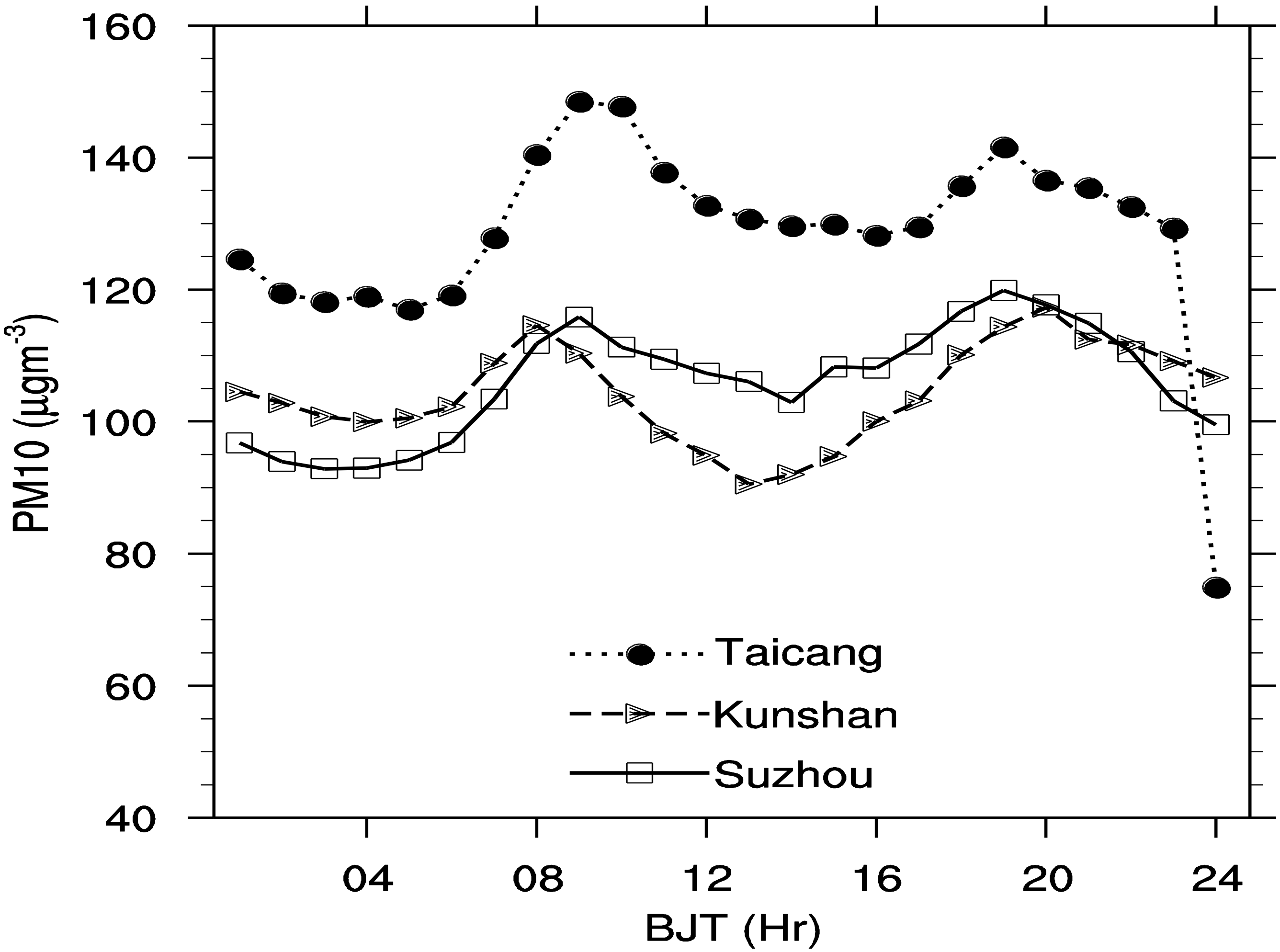

Fig.3 Diurnal pattern of PM_{10} (yearly mean) in 2011

Diurnal pattern of $PM_{2.5}$ in spring

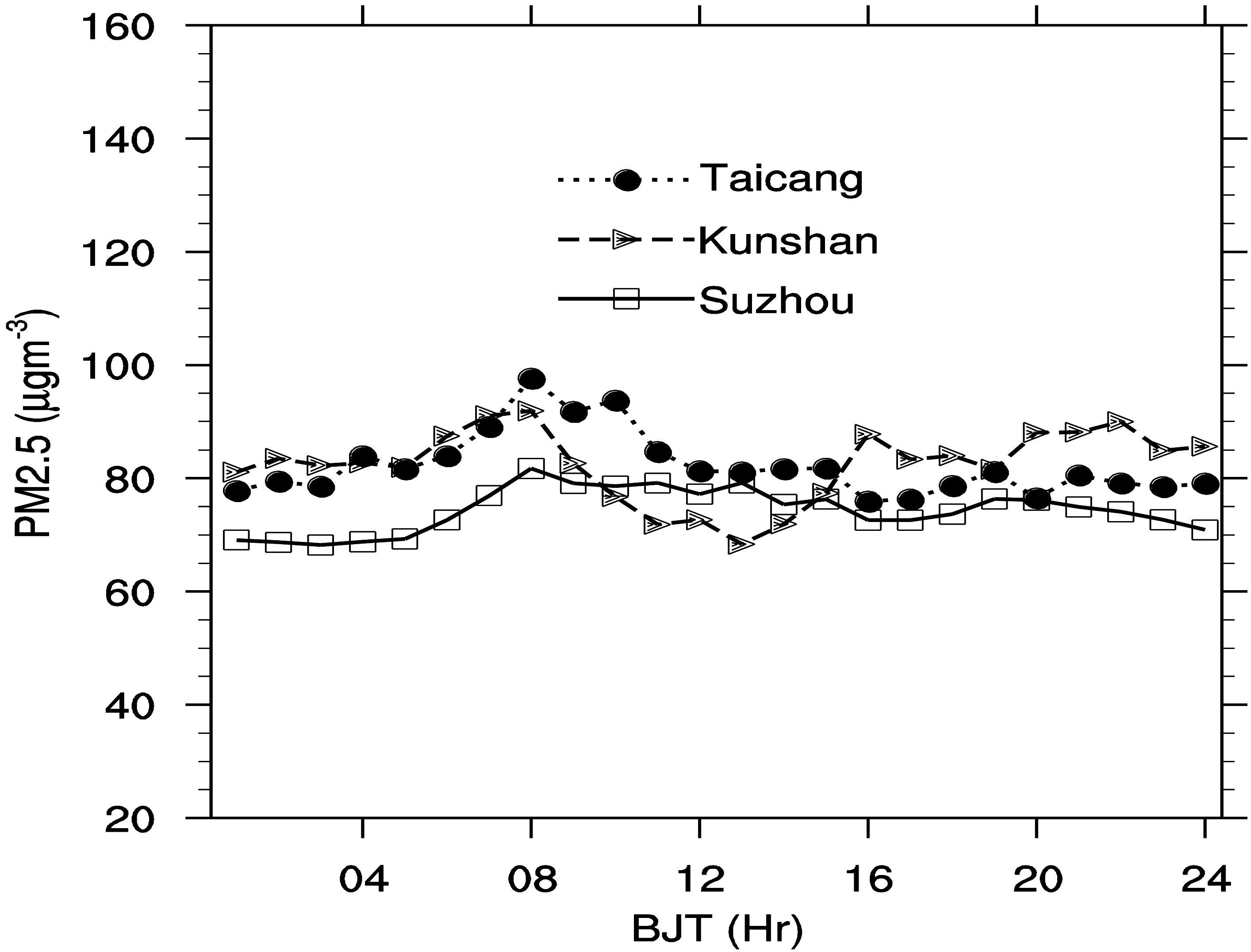

Fig.4 Diurnal pattern $PM_{2.5}$ in spring 2011

Diurnal pattern of $PM_{2.5}$ in summer

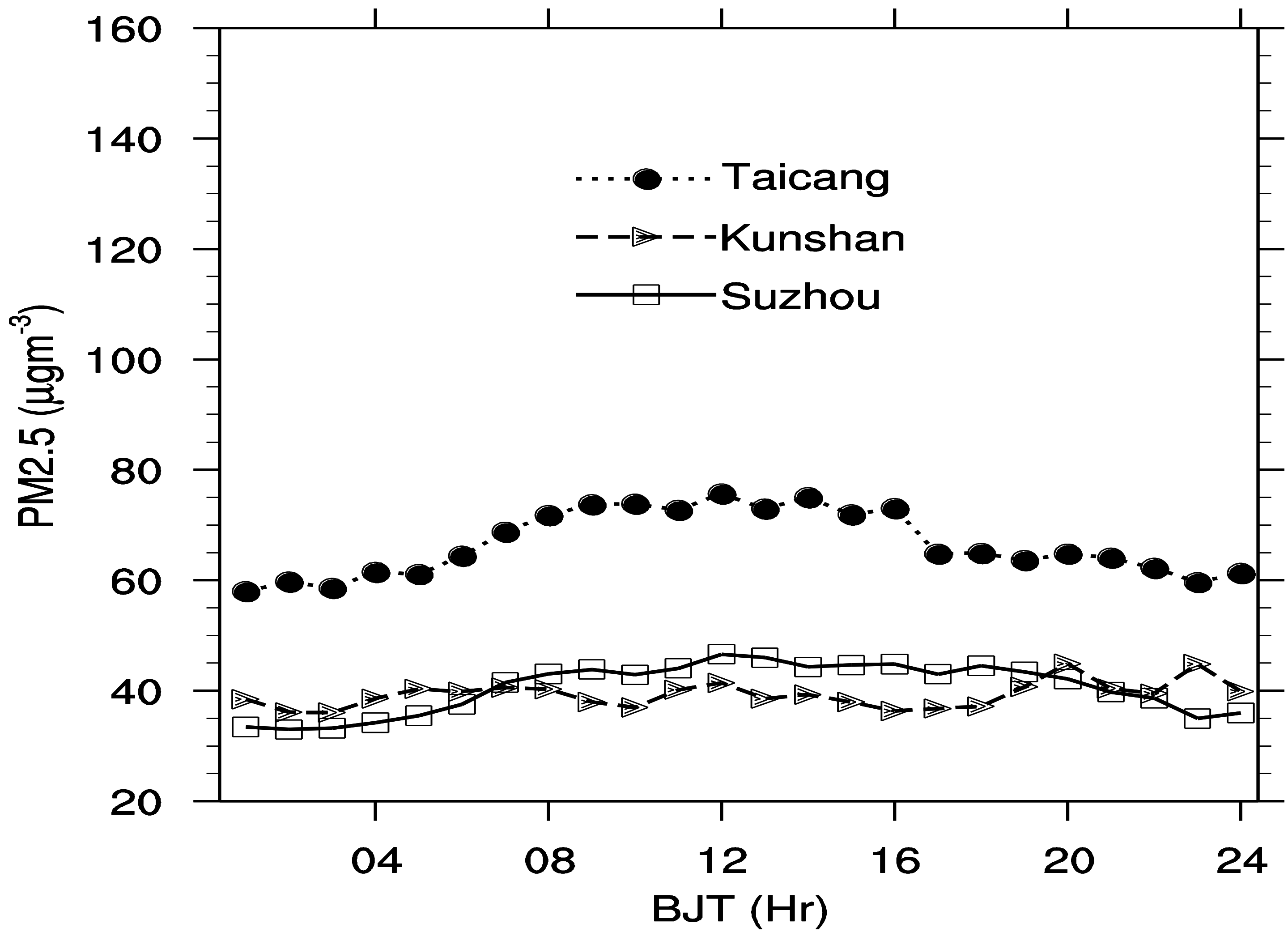

Fig.5 Diurnal pattern PM2.5 in summer 2011

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Diurnal pattern of $PM_{2.5}$ in autumn

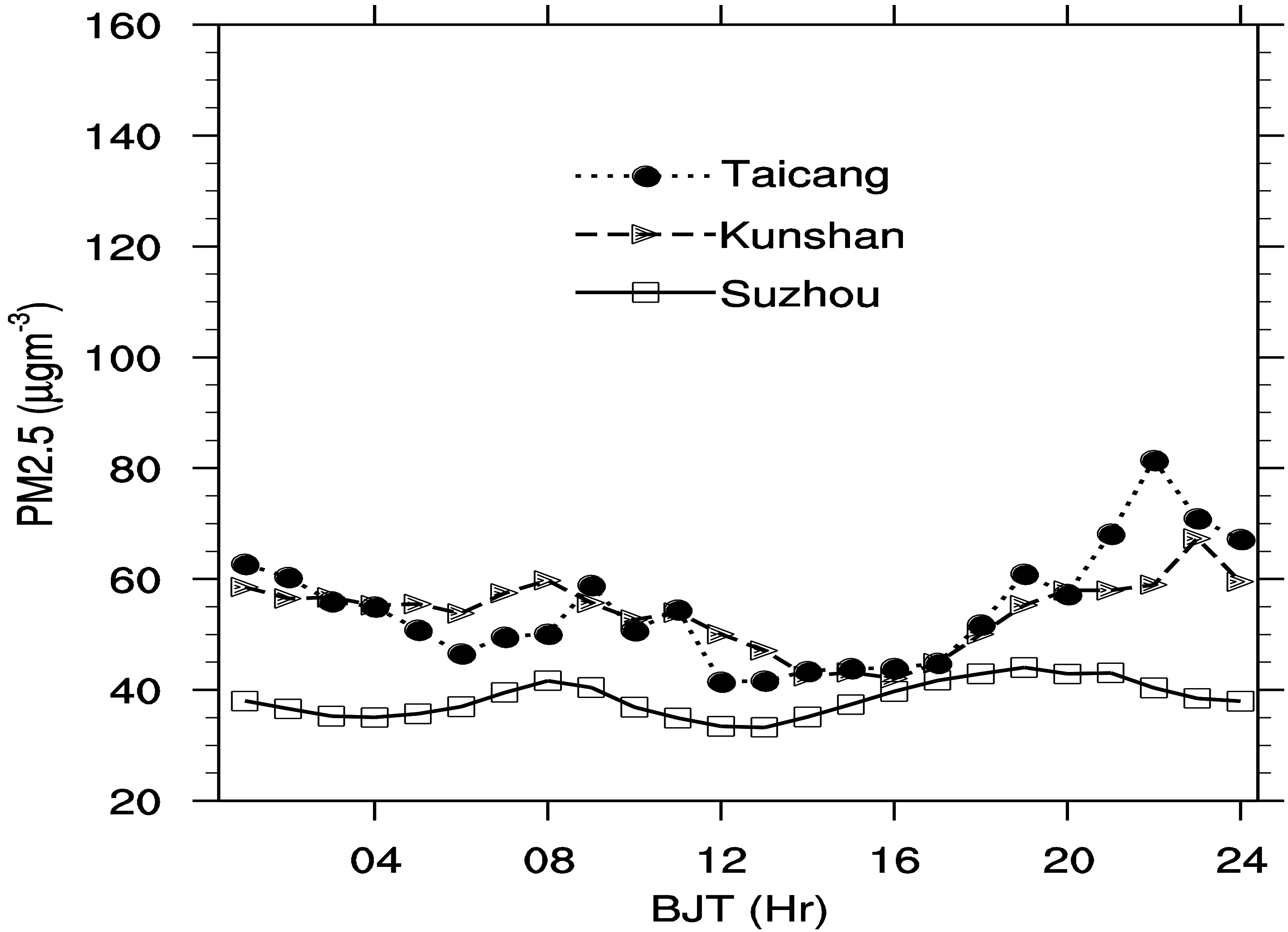

Fig.6 Diurnal pattern of $PM_{2.5}$ in autumn 2011

Diurnal pattern of $PM_{2.5}$ in winter

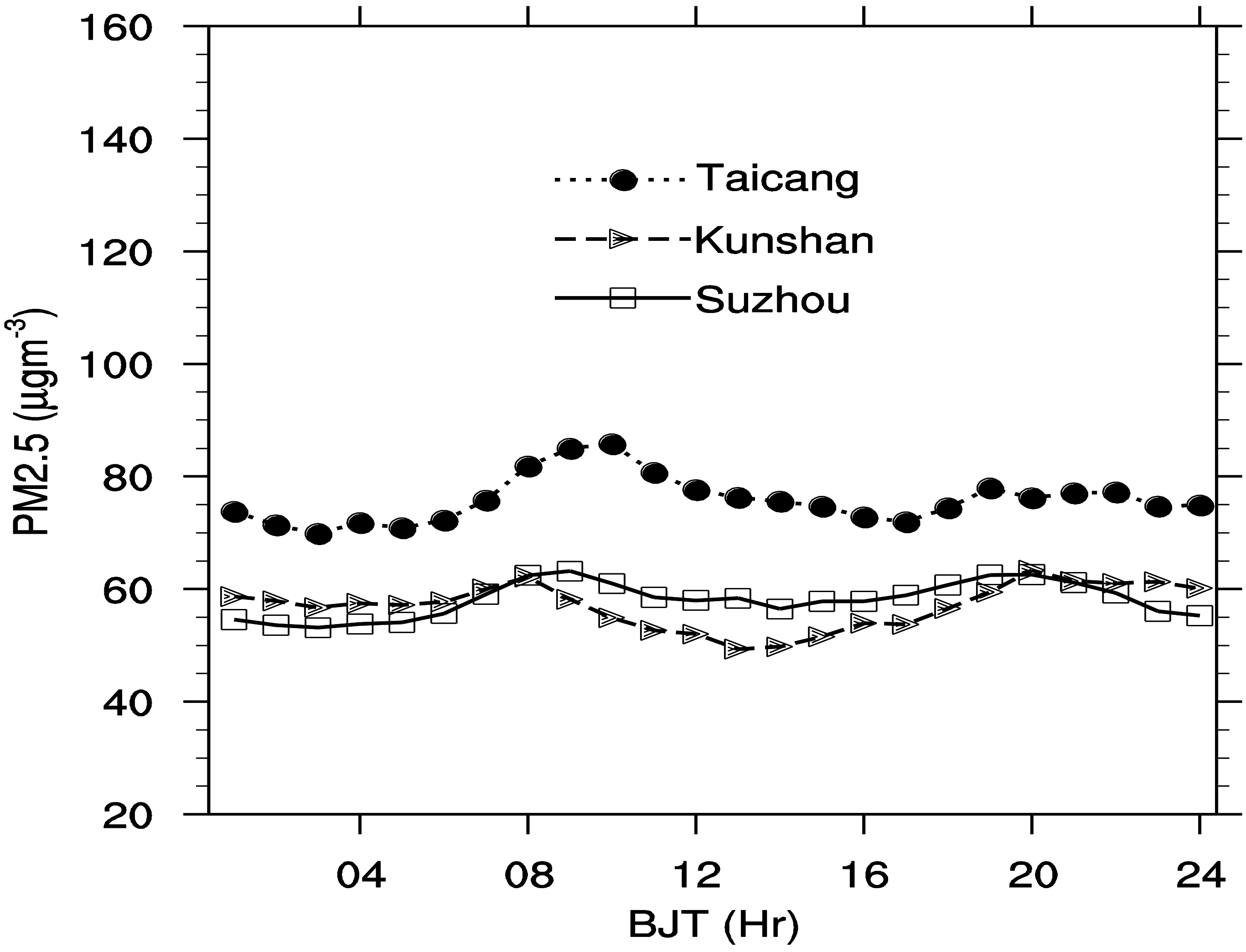

Fig.7 Diurnal pattern PM2.5 in winter 2011

Diurnal pattern (weekday vs. weekend)

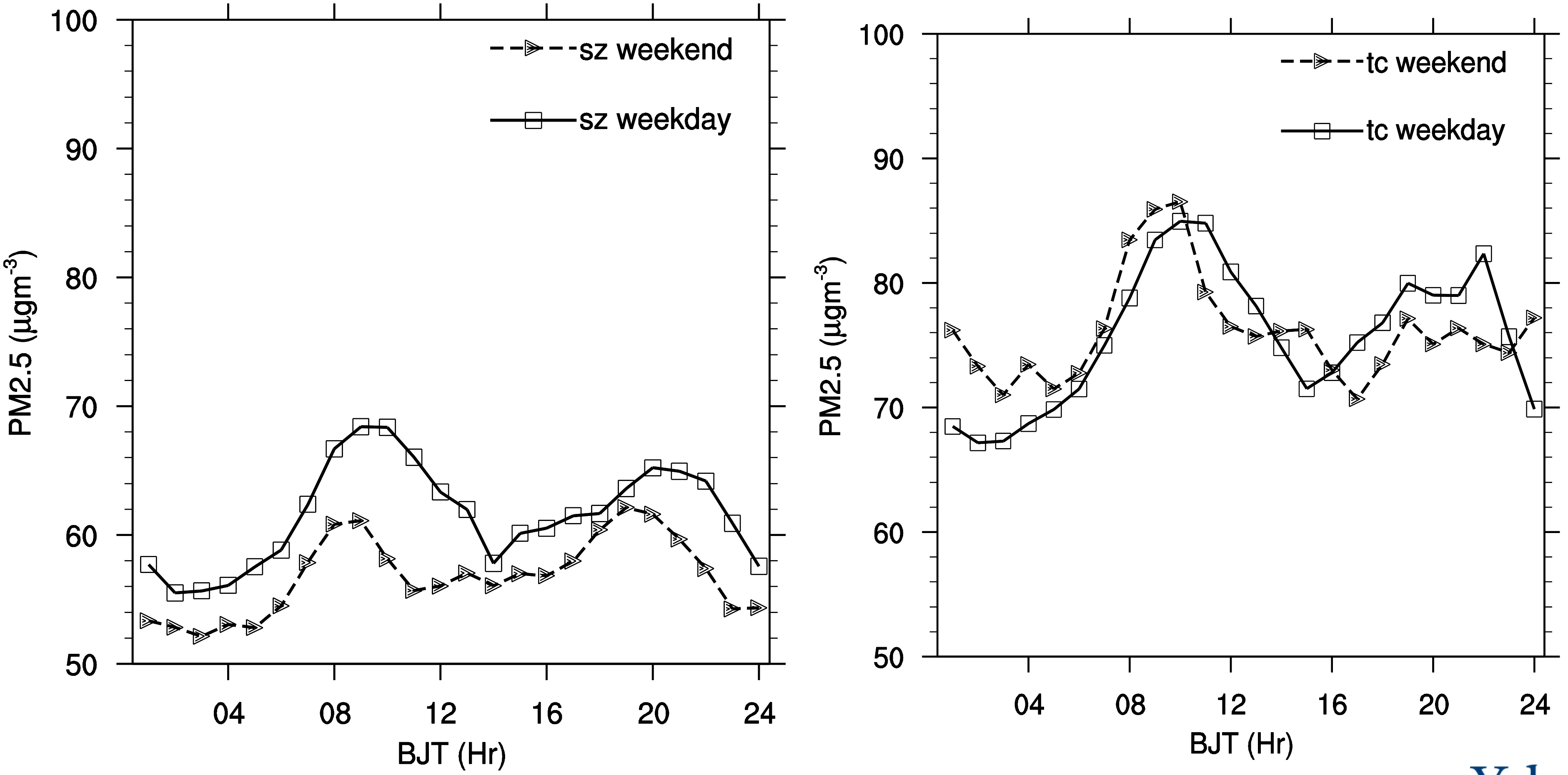

Fig.8 Diurnal pattern (weekday vs. weekend)

Relationships of $PM_{2.5}$ with other species（year）

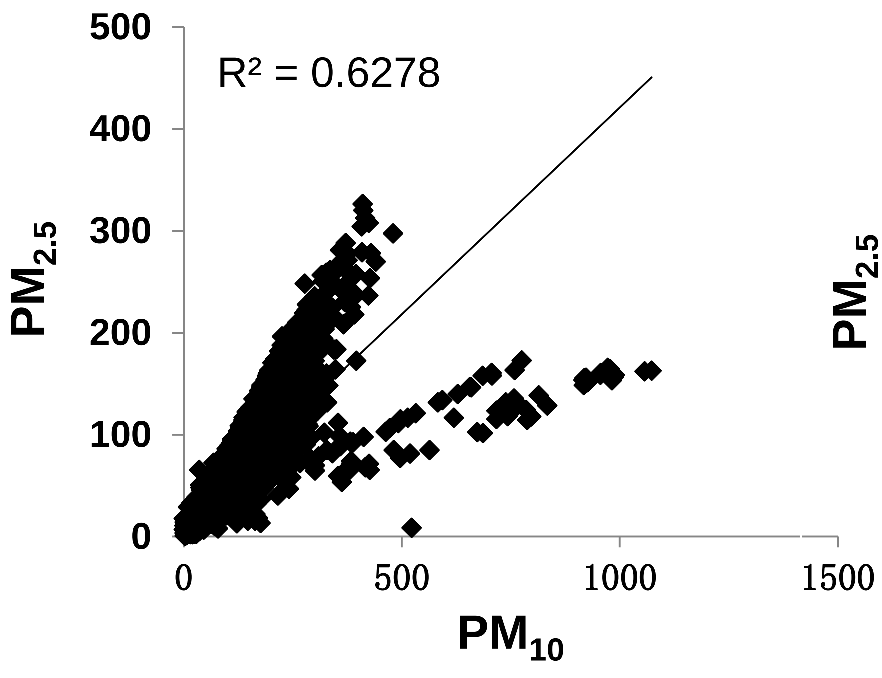

Fig.10 $PM_{2.5}$ versus PM_{10}

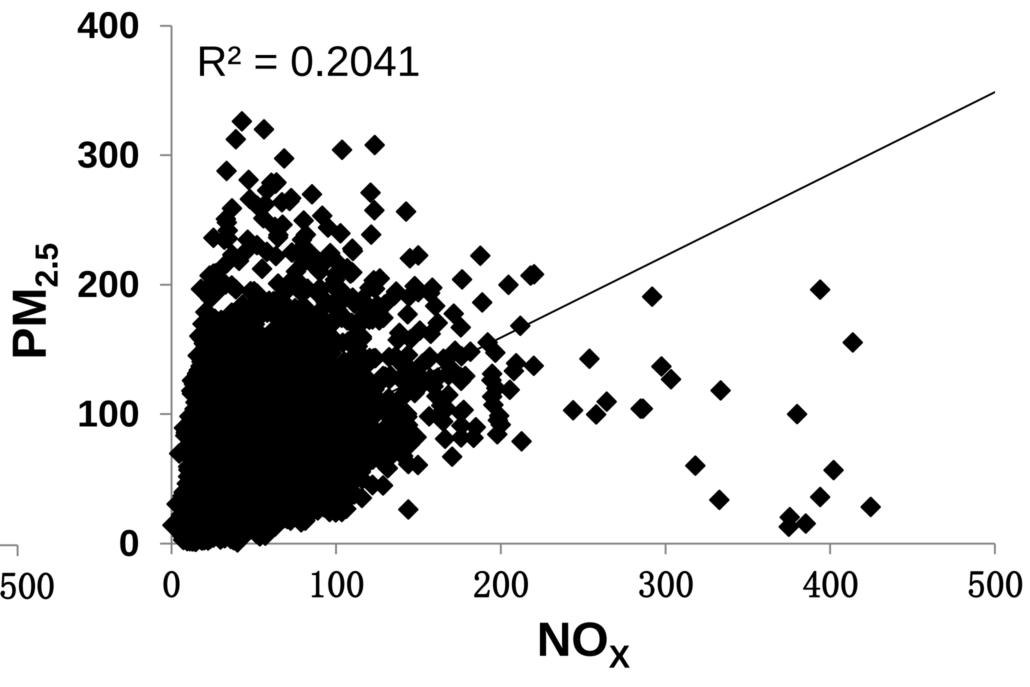

Fig.11 $PM_{2.5}$ versus NO_X

Relationships of $PM_{2.5}$ with other species (cont.)

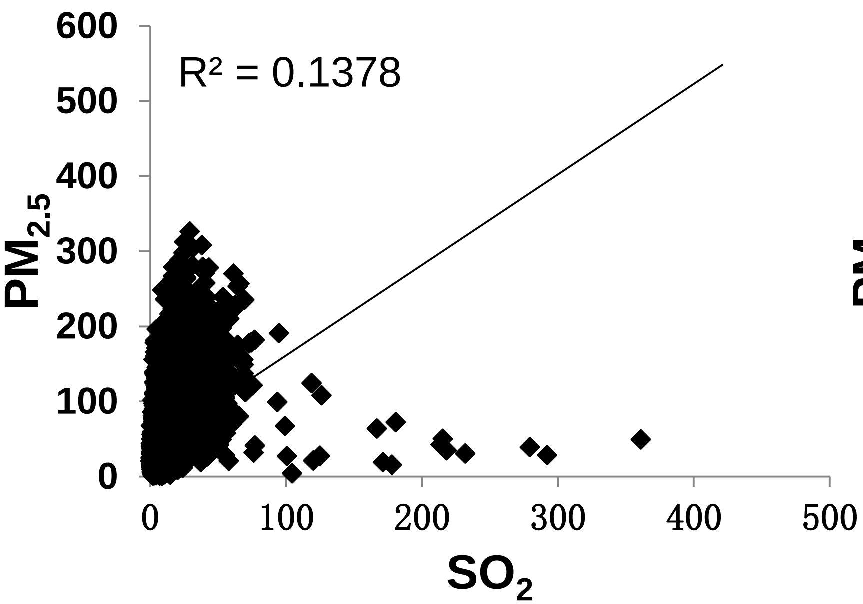

Fig.12 $PM_{2.5}$ versus SO_2

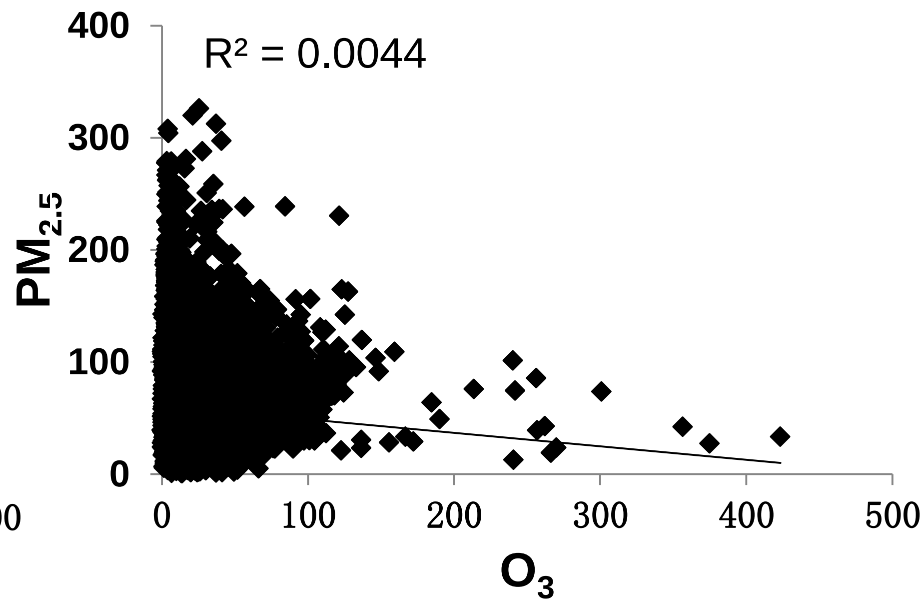

Fig.13 $PM_{2.5}$ versus O_3

Relationships of $PM_{2.5}$ with other species（winter）

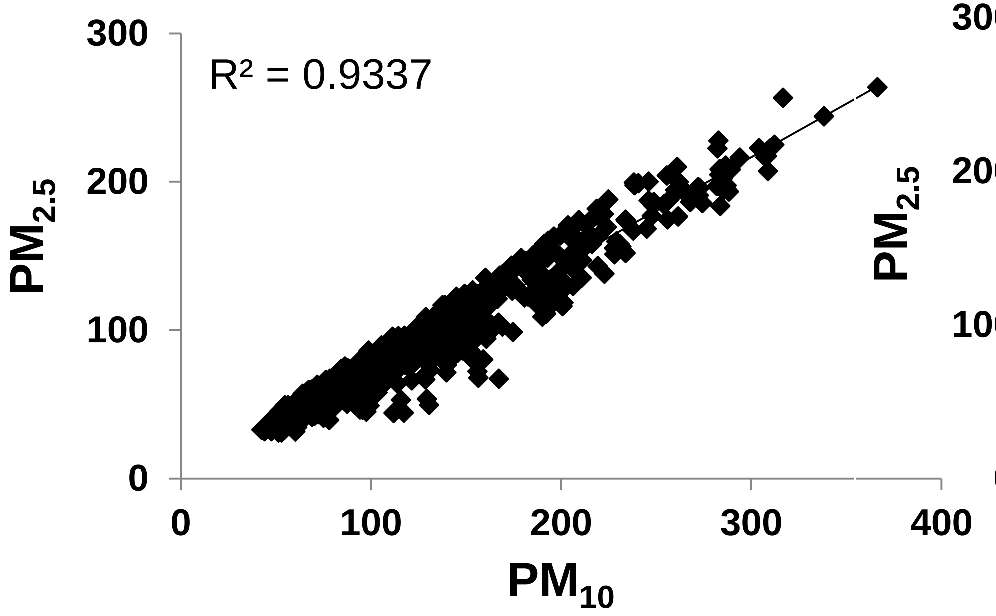

Fig.14 $PM_{2.5}$ versus PM_{10}

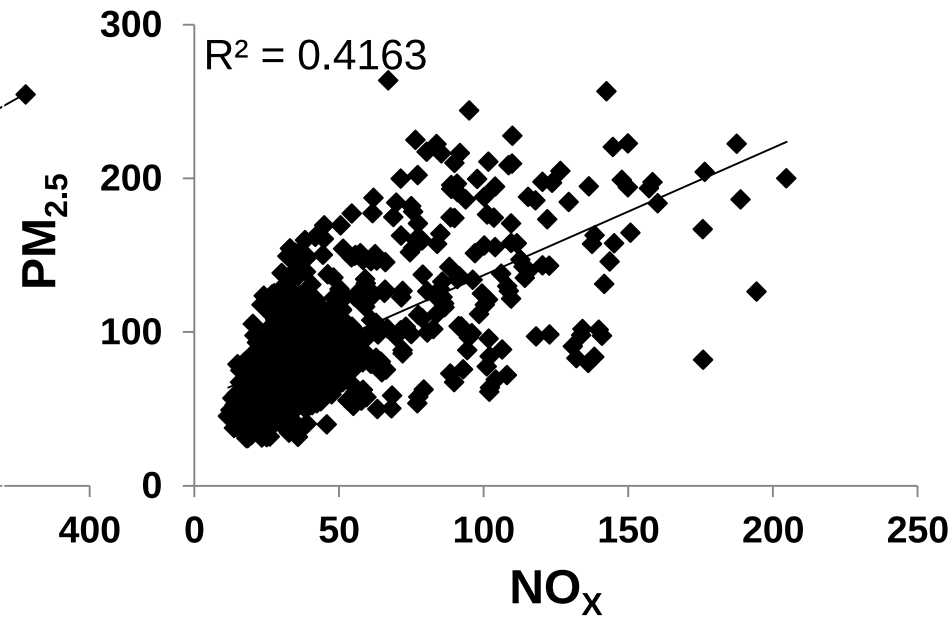

Fig.15 $PM_{2.5}$ versus NO_X

Relationships of $PM_{2.5}$ with other species (cont.)

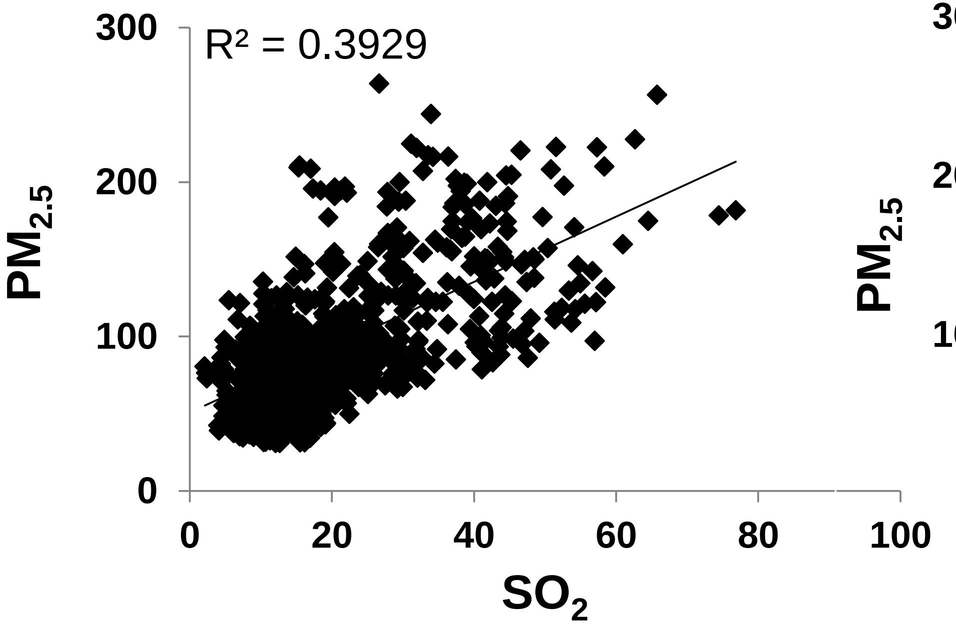

Fig.16 $PM_{2.5}$ versus SO_2

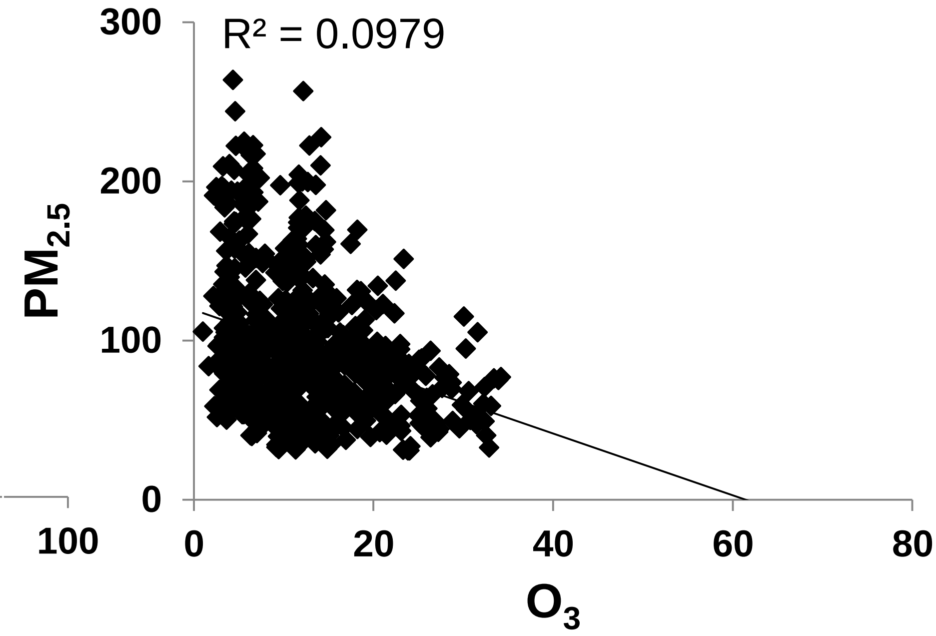

Fig.17 $PM_{2.5}$ versus O_3

$PM_{2.5}$ versus other species (R^2)

Table.4 The relationship (R2) between $PM_{2.5}$ and various pollutants

	Spring	Summer	Autumn	Winter	Year
Ozone	0.01	0.06	0.01	**0.09**	0.00
NO_x	0.18	0.06	0.27	**0.41**	0.20
SO_2	0.25	0.02	0.16	**0.39**	0.14
PM_{10}	0.79	0.88	0.90	**0.93**	0.62

$PM_{2.5}$ versus meteorological variables

Table.5 The relationship (R^2) between $PM_{2.5}$ and meteorological variables

	Spring	**Summer**	**Autumn**	**Winter**	**Year**
Relative humidity	0.00	0.00	**0.01**	0.01	0.05
Temperature	**0.12**	0.02	0.08	0.07	0.09

Days exceeding CNAQS of $PM_{2.5}$

Table.6 Exceedance days of $PM_{2.5}$ observed at Suzhou site in four seasons, 2011

$PM_{2.5}$ (μg/m3)	Spring	Summer	Autumn	Winter	Year
0—35 Very good	9	42	50	12	113
35—75 good	44	45	32	34	155
75 and above below grade	39	5	8	41	93

Case study
high concentrations of $PM_{2.5}$

Table.7 Maximum and hourly mean $PM_{2.5}$ during 150-154 of 2011

		Kunshan	Suzhou	Taicang
PM2.5 ($\mu g/m^3$)	Highest	235.6	399.4	235.9
	Hourly mean	150.2	110.6	147.5

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Time series of $PM_{2.5}$

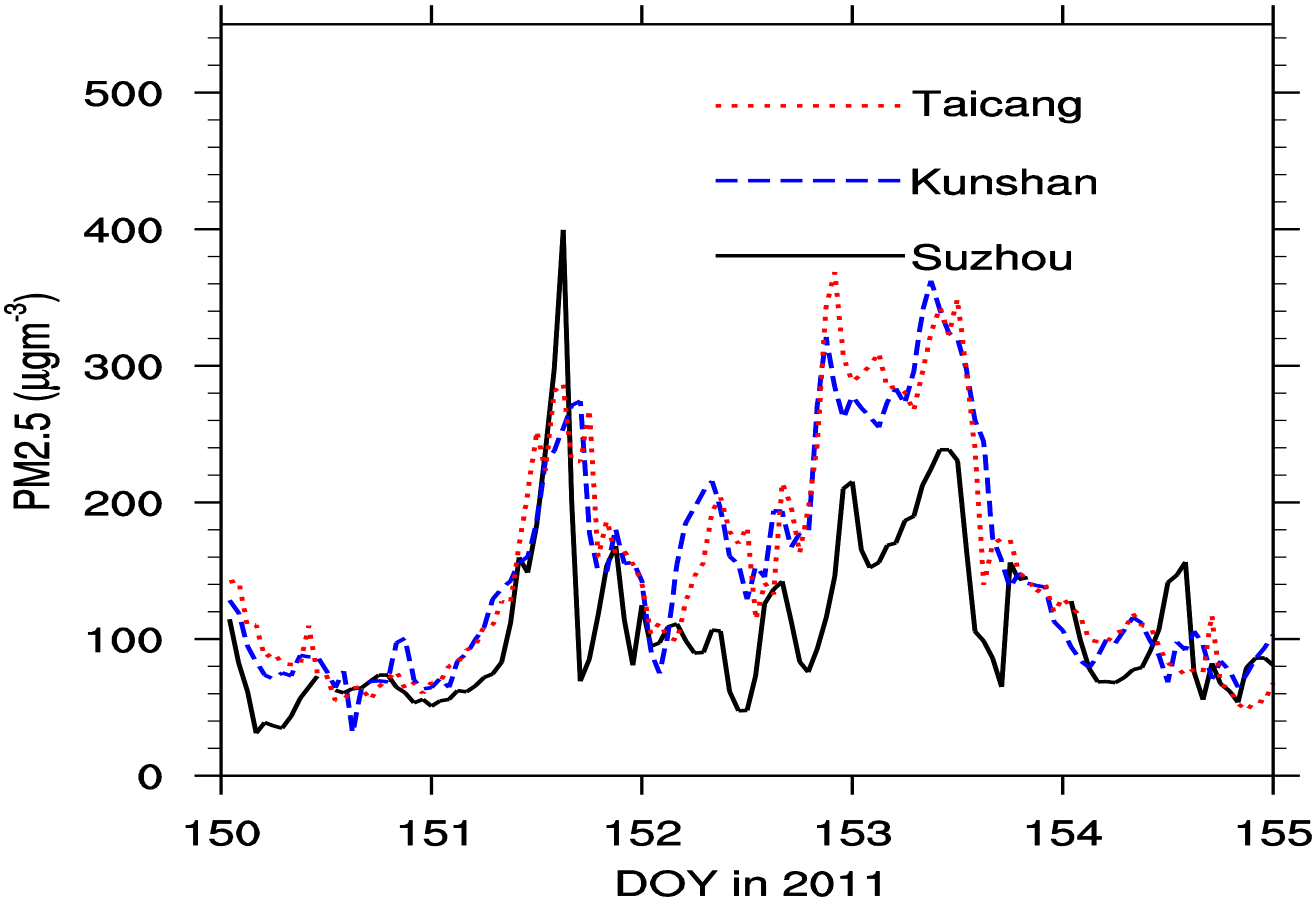

Fig.18 $PM_{2.5}$ during the days of 150-154 in 2011

Surface weather chart

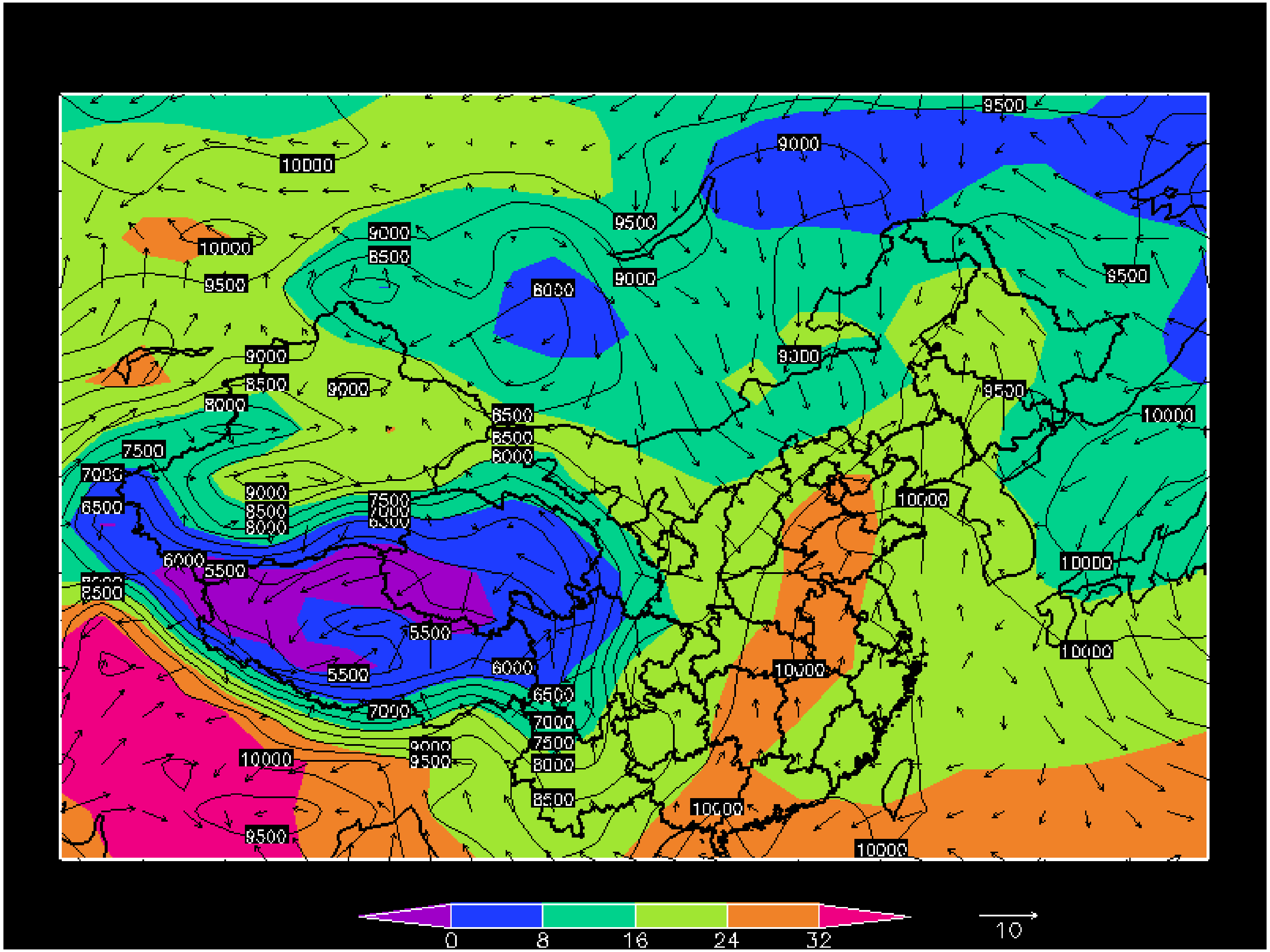

Fig.19 Weather chart at during 150-154

850hPa weather chart

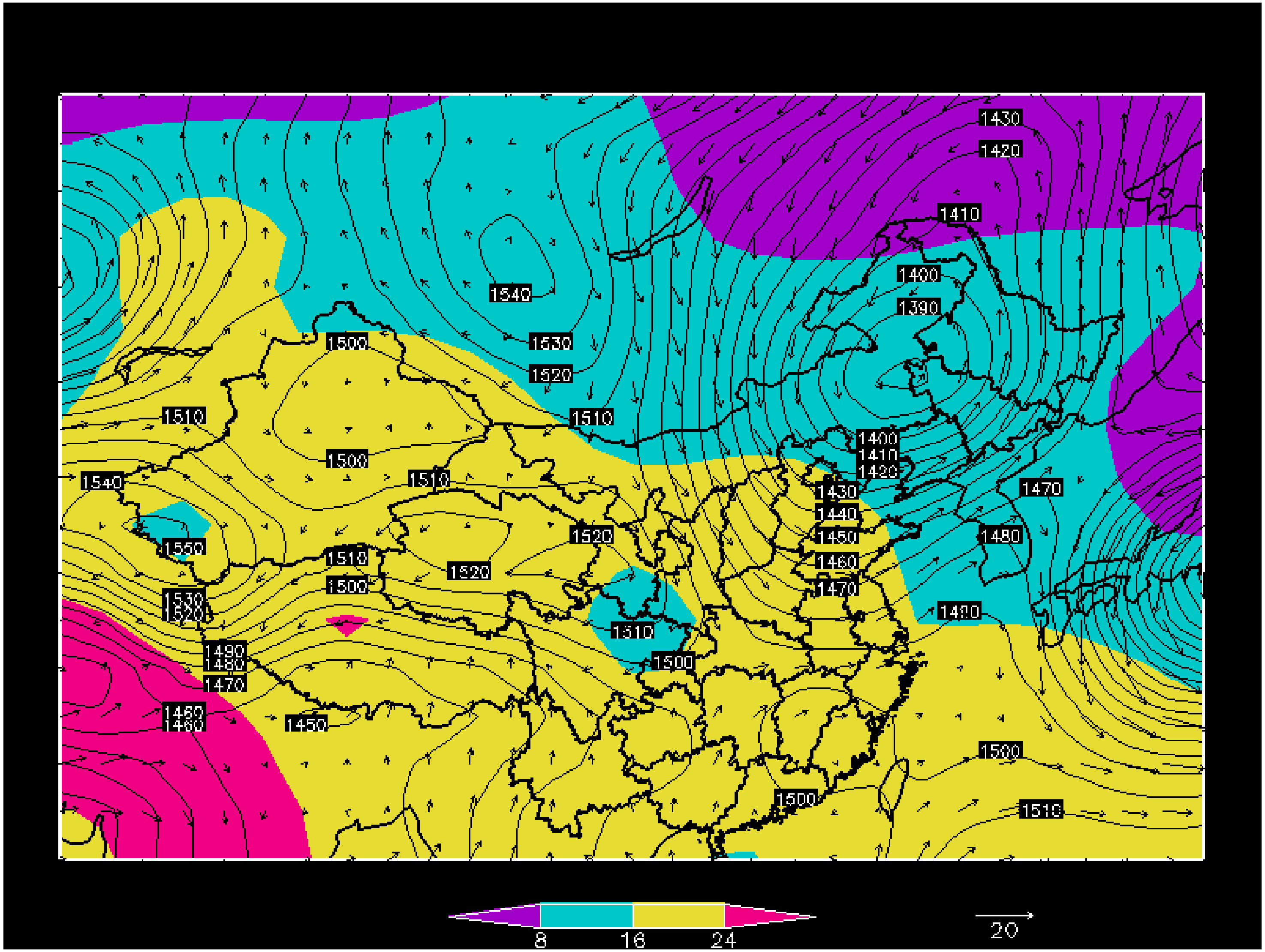

Fig.20 850hPa weather chart during 150-154

Time series of T and RH

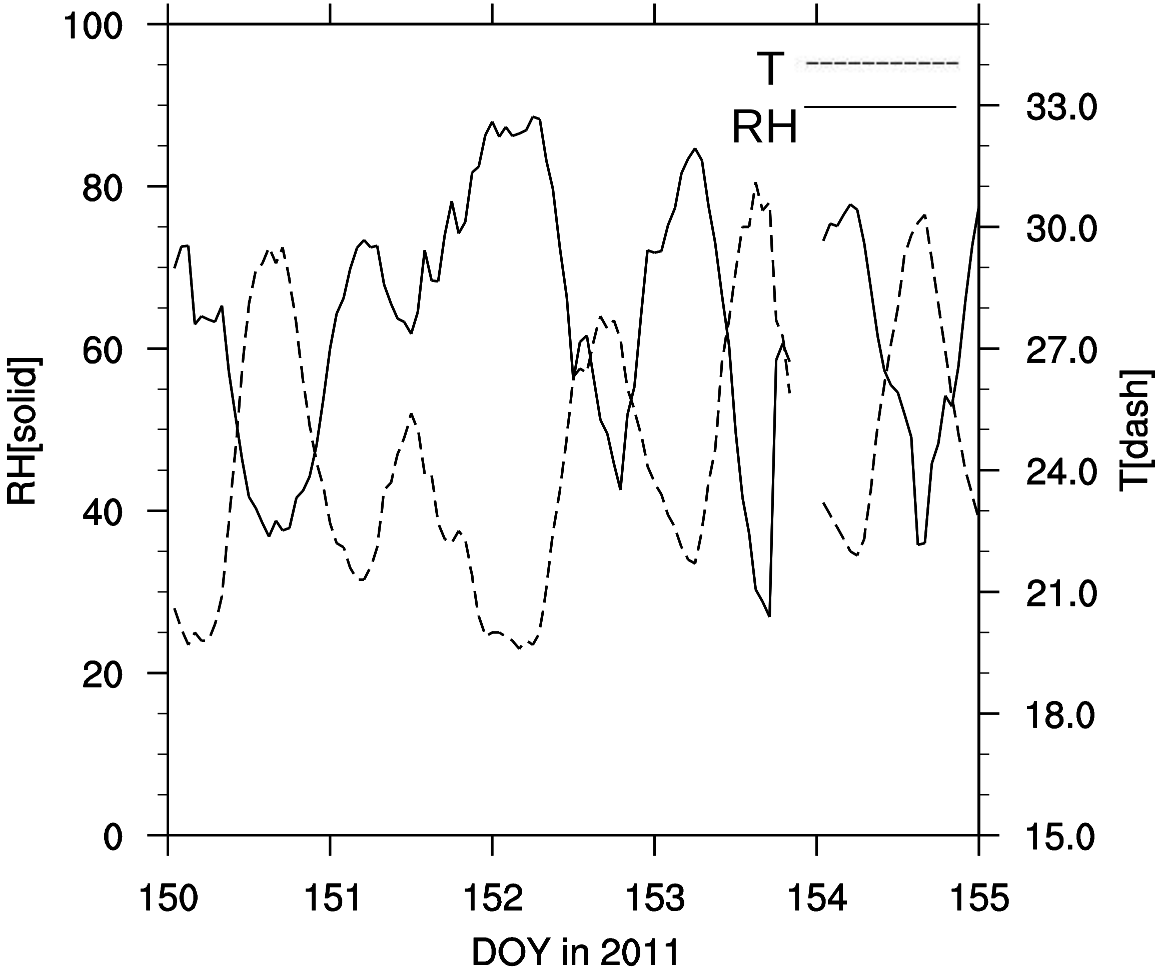

Fig.21 Time series of T and RH observed at Suzhou during DOY 150-154

Impact of meteorological conditions

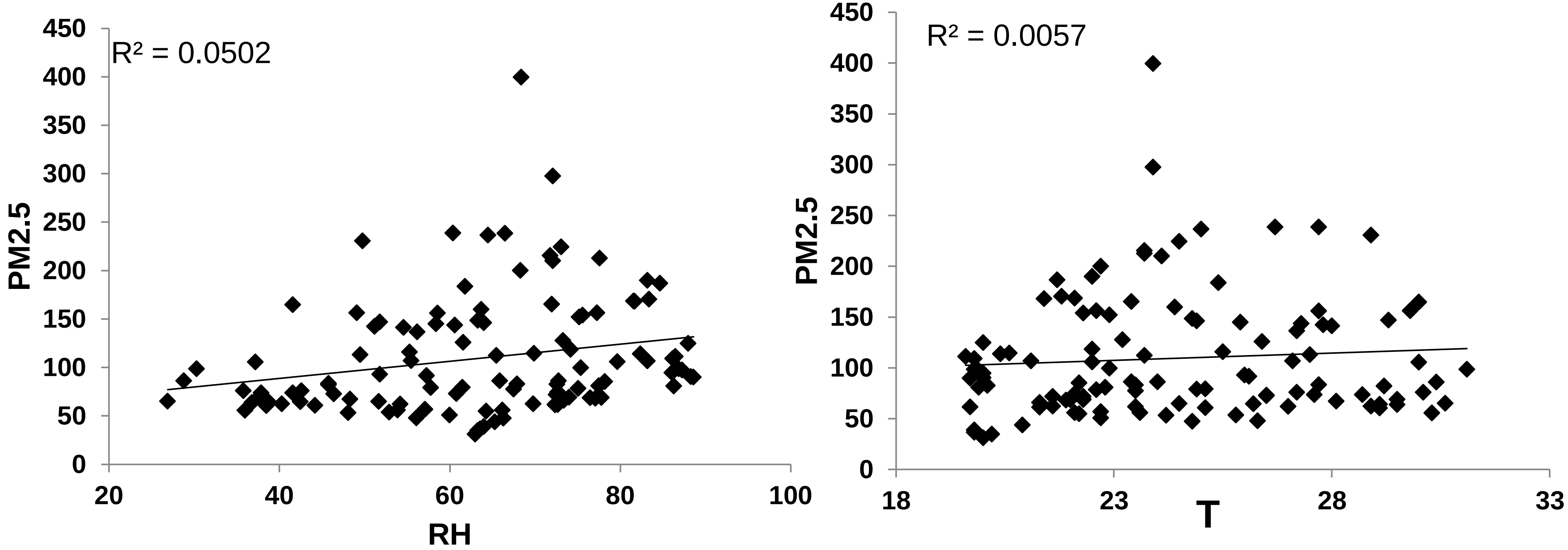

Fig.22 Concentrations of $PM_{2.5}$ vs RH and $PM_{2.5}$ vs T during 150-154 in Suzhou

Time series of O_3, NO_x, and SO_2

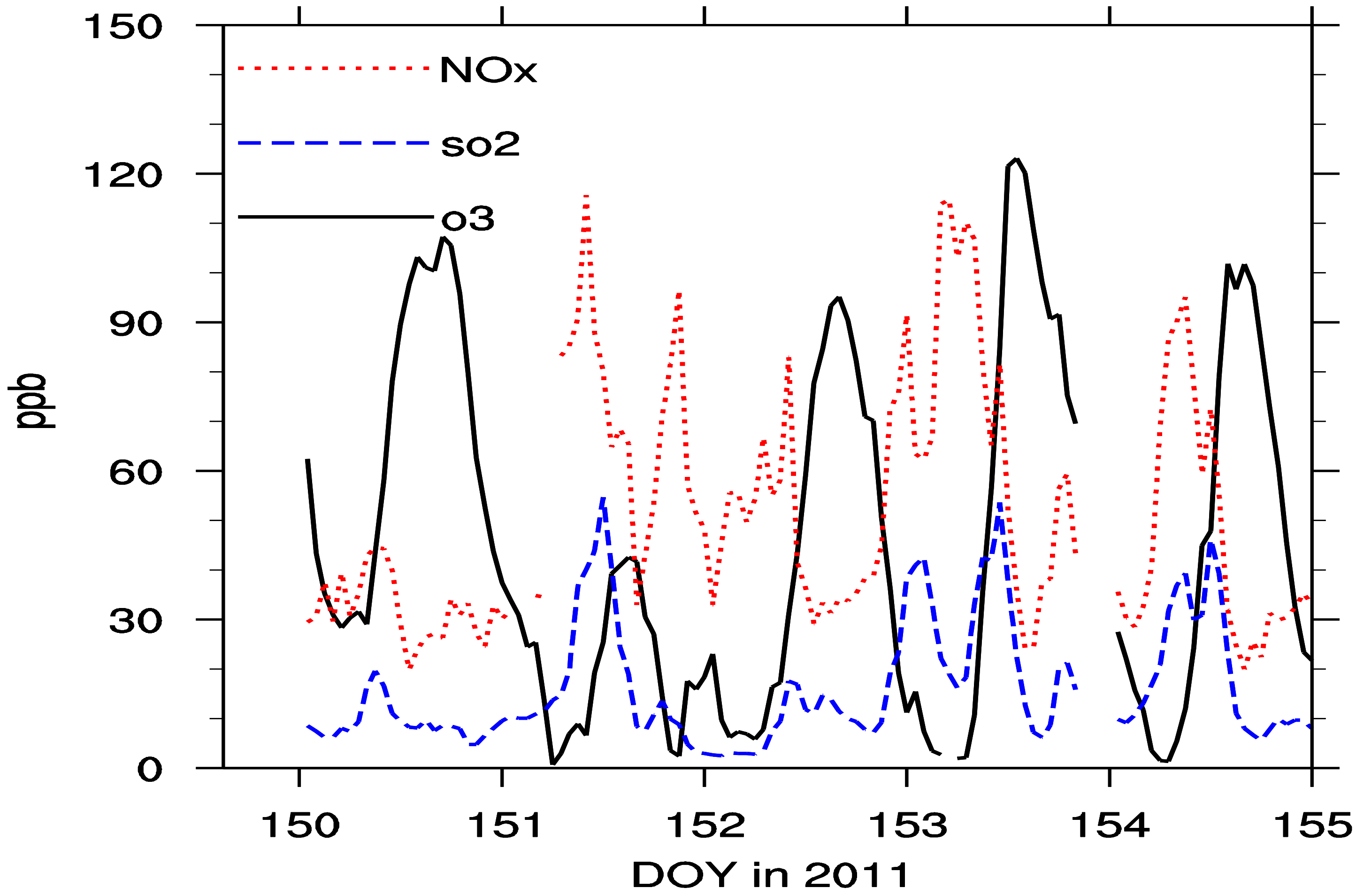

Fig.23 Concentrations of other species during 150-154 in the three sites

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Impact of meteorological conditions

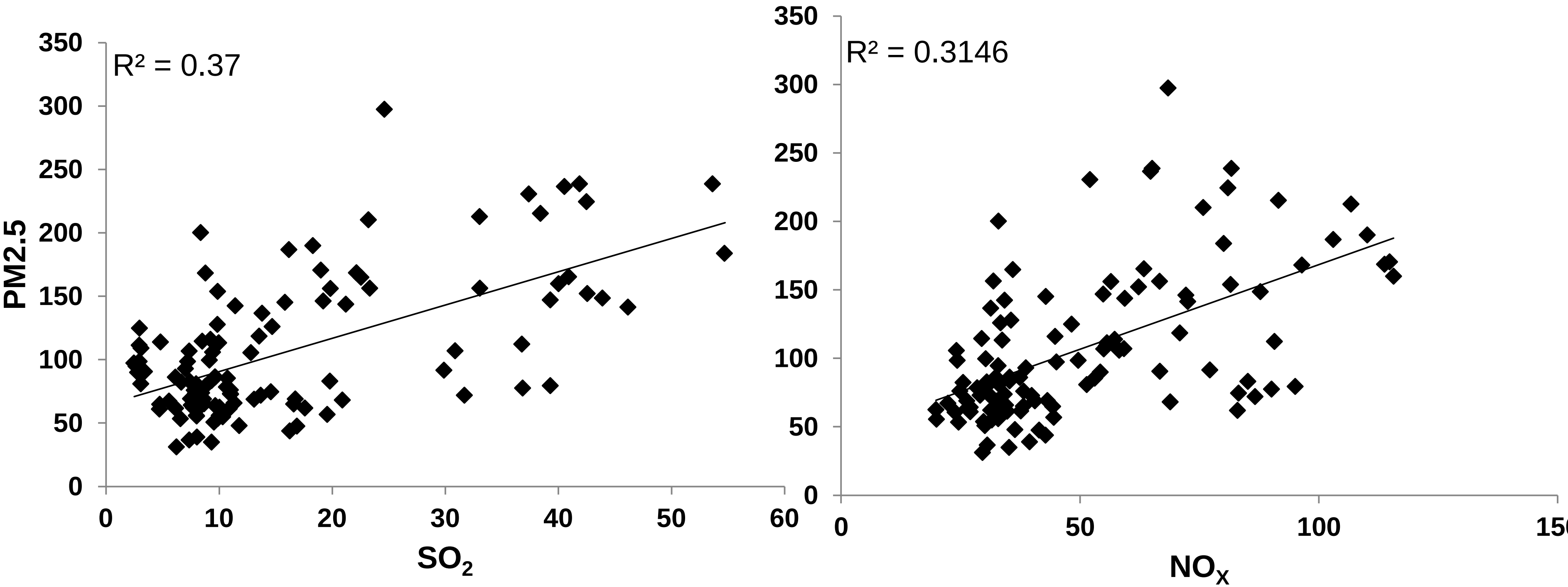

Fig.24 Concentrations of $PM_{2.5}$ vs SO_2 and $PM_{2.5}$ vs NO_X during 150-154 in Suzhou

Summary

- Diurnal patterns show

  - strong peak in the morning and weak peak in the afternoon, indicating the important impact of human activities

  - evident variations in the four seasons except for summer.

- Seasonal patterns show

  - higher concentrations in winter and spring, lower values in summer, indicating the impact of meteorological conditions

Summary (cont.)

- $PM_{2.5}$ became a serious air quality problem in Suzhou and surrounding regions. The USNAQS of $PM_{2.5}$ was exceeded on 68% of total days in 2011 (Suzhou).
- R^2 values show that very little dependence of $PM_{2.5}$ on other pollutants (e.g., SO_2, No_x, and O_3), and on temperature and relative humidity. Other important meteorological variables such as weather systems and PBL heights need further investigation, especially for $PM_{2.5}$ episodes.

Next step

- Do more detailed analysis
- Analyze 2012 observational data
- Write a manuscript for journal publication

Thank you