Yale-NUIST Center on Atmospheric Environment

Simulation and evaluation of haze day in Jiangsu province based on WRF/CMAQ

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Outline

- Introduction
- Model and Data
- Methods
- Results
- Discussions and next work

Introduction

- Under the global warming background conditions, haze days for a long time influenced by various climatic factors, such as visibility, relative humidity, temperature and wind speed are the important factors. The number of haze days nearly 60 years shows a clear upward trend(Wu et al.,2016).

- Numerical simulation is an important method for the prediction and the research of haze days. WRF/CMAQ is one of the most common numerical model. In China, CMAQ also has some of the related research, such as the emission reduction of air quality in Beijing (Xing et al.,2011).

Introduction

- The forecast of haze day is an important indexes for the prediction of air pollution. In 2010, the National Meteorological Bureau promulgated the standard, which defined that the daily visibility is less than 10 km, the daily average relative humidity is less than 80%, or daily average relative humidity is between 80% ~ 95% and PM2.5 concentration is greater than 75 μg/m3 , judged as haze day.

- Using WRF/CMAQ model, to simulate haze days by meteorological elements and pollutant concentration from October 2014 to March 2015 in Jiangsu Province.

Model and Data

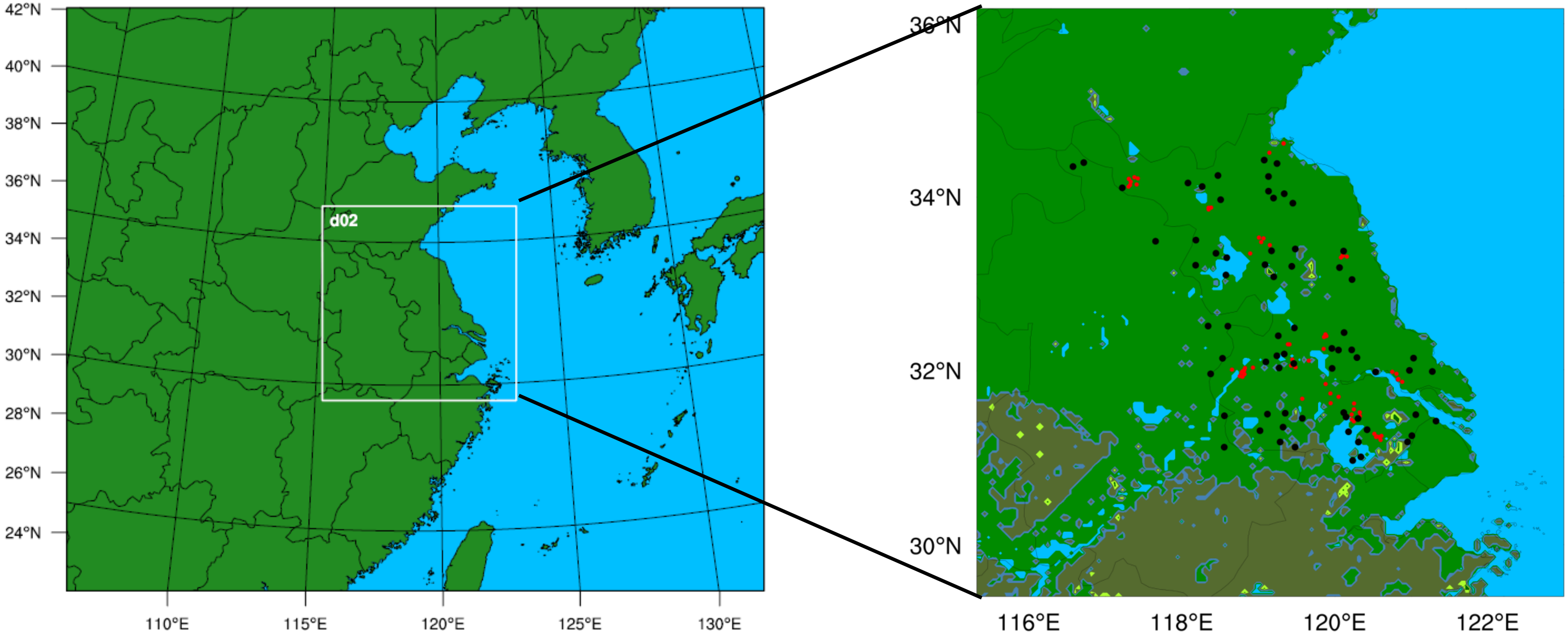

Fig.1 Two nested modeling domains(Meteorological stations are black spots, environment monitor stations are red spots).

Model and Data

Table. 1 Parameter settings

Domain		1	2
Time		Oct 1st,2014 to Mar 31th, 2015	
Initial meteorological field		Fnl(1° ×1°)	
Center		33.0° N, 119.0° E	
Vertical stratification		28 levels	
Horizontal grid point		WRF： 180 × 150 CMAQ： 160 × 130	WRF： 150 × 150 CMAQ： 130 × 130
Horizontal resolution		15km	5km
mp_physics		Lin et al. scheme	
ra_sw_physics		Goddard shortwave	
sf_surface_physics		Noah Land Surface Model	
CCTM	The horizontal advection and vertical convection	PPM	
	The vertical diffusion	Crank-Nicholson	
	Chemical mechanism	CB05(CB05-AE6-AQ)	
	Emissions plume	Smoke	

Model and Data

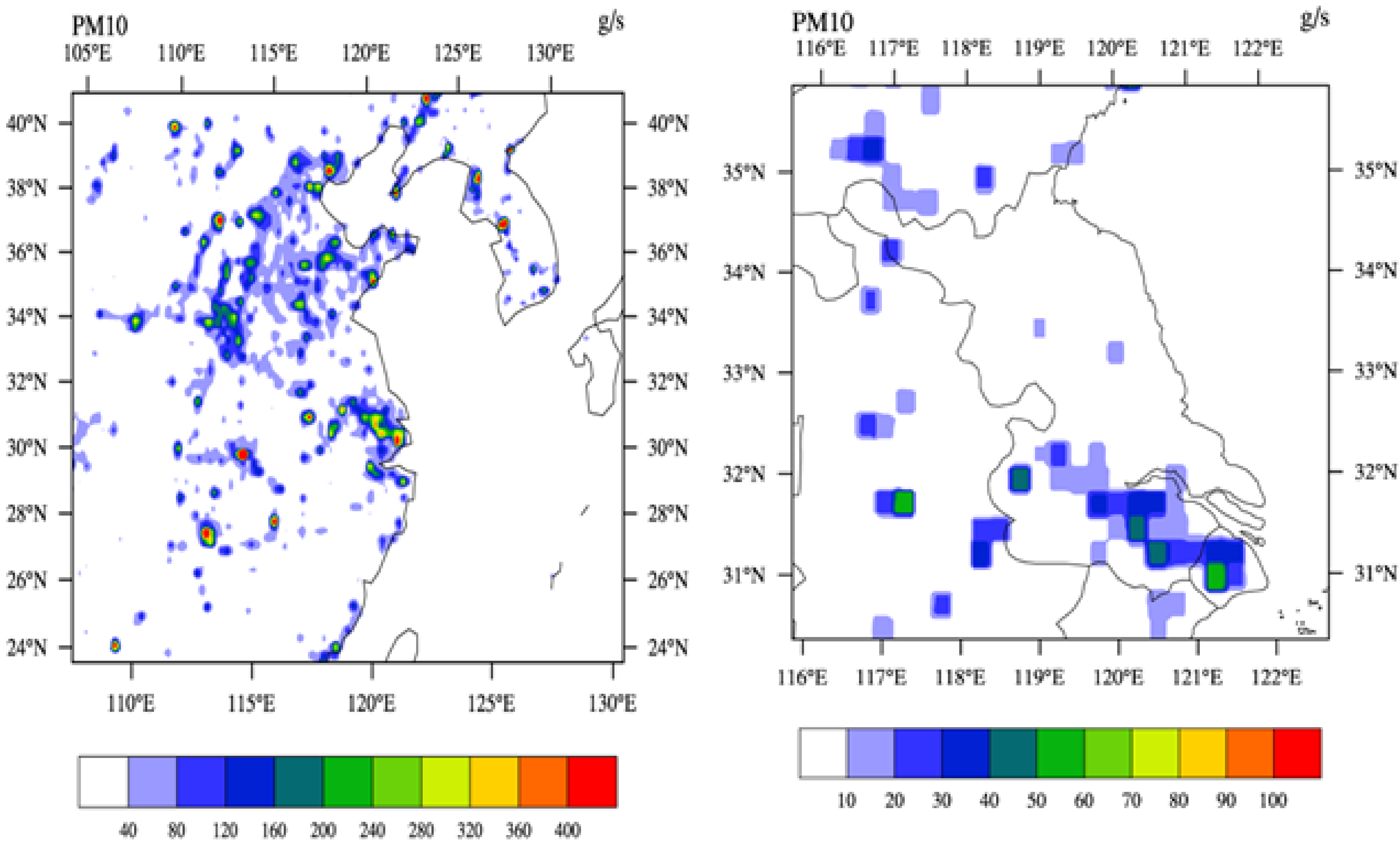

Fig.2 Two nested modeling domains and primary PM10 emission rates from Tsinghua University in 2010.

Methods

Calculation of Atmospheric Visibility based on Koschmieder law.

$$V_R = {}^{3.91}/_{\beta_{ext}}$$

The method is explained by Malm et al. (1994). The formula used here is a slight modification of their Equation(Sisler, 1998).

$$\beta_{ext}\left[\frac{1}{km}\right] = 0.003 \times f(rh) \times \{[ammonium\ sulfate] + [ammonium\ nutrate]\}$$
$$+0.004 \times [organic\ mass] + 0.01 \times [light\ absorbing\ carbon]$$
$$+0.001 \times [fine\ soil] + 0.0006 \times [coarse\ mass]$$

Ammonium sulfate and ammonium nitrate were taken as the sum of ammonium, plus sulfate, plus nitrate. Organic mass was taken as the sum of all organic species. Light absorbing carbon was taken as elemental carbon. Fine soil was taken as the unspeciated portion of PM2.5 emitted species, and the coarse mass term was not implemented in CMAQ at this time.

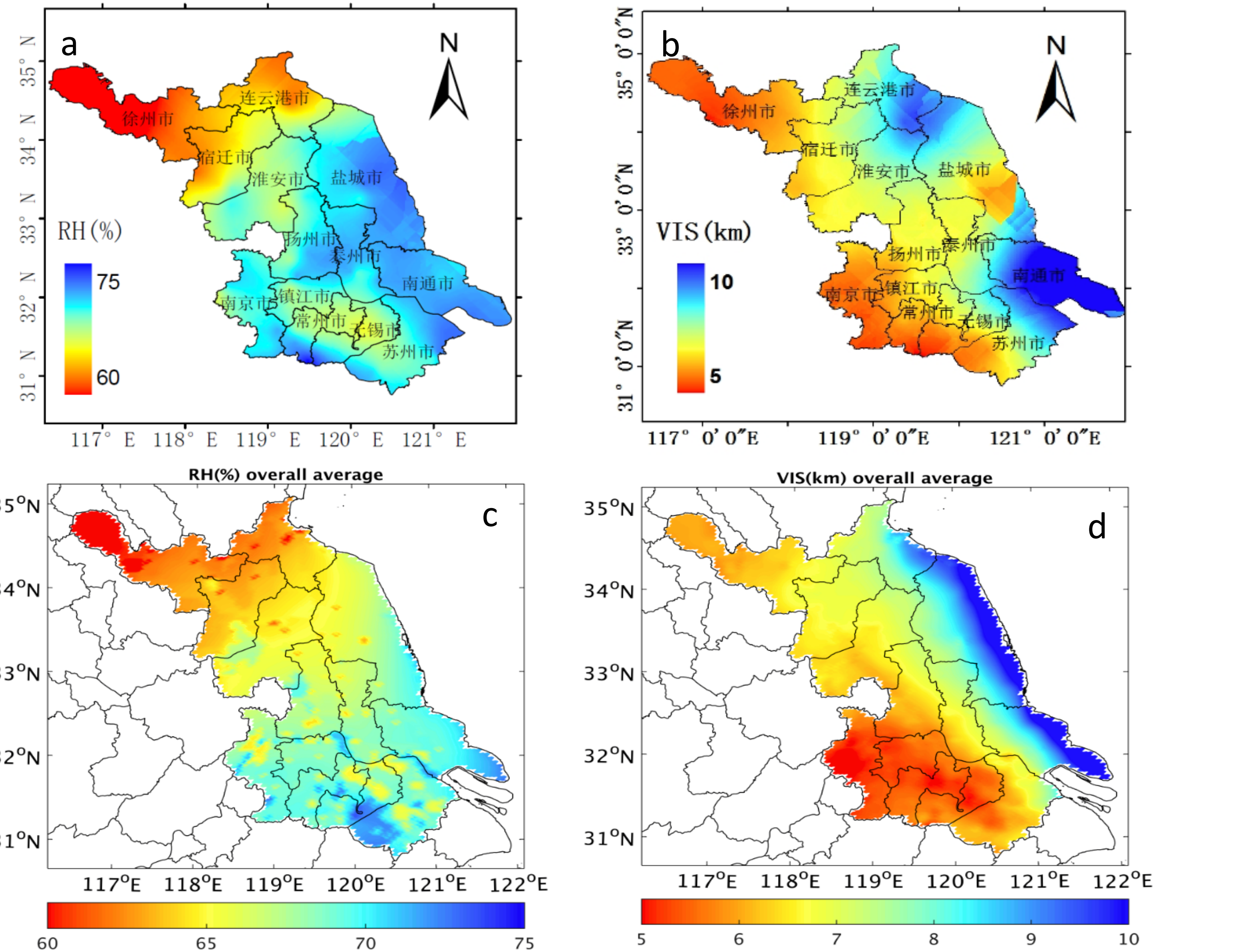

Fig.3 Daily average of relative humidity and visibility (a, b) and simulations(c, d) in winter of 2014.

Results

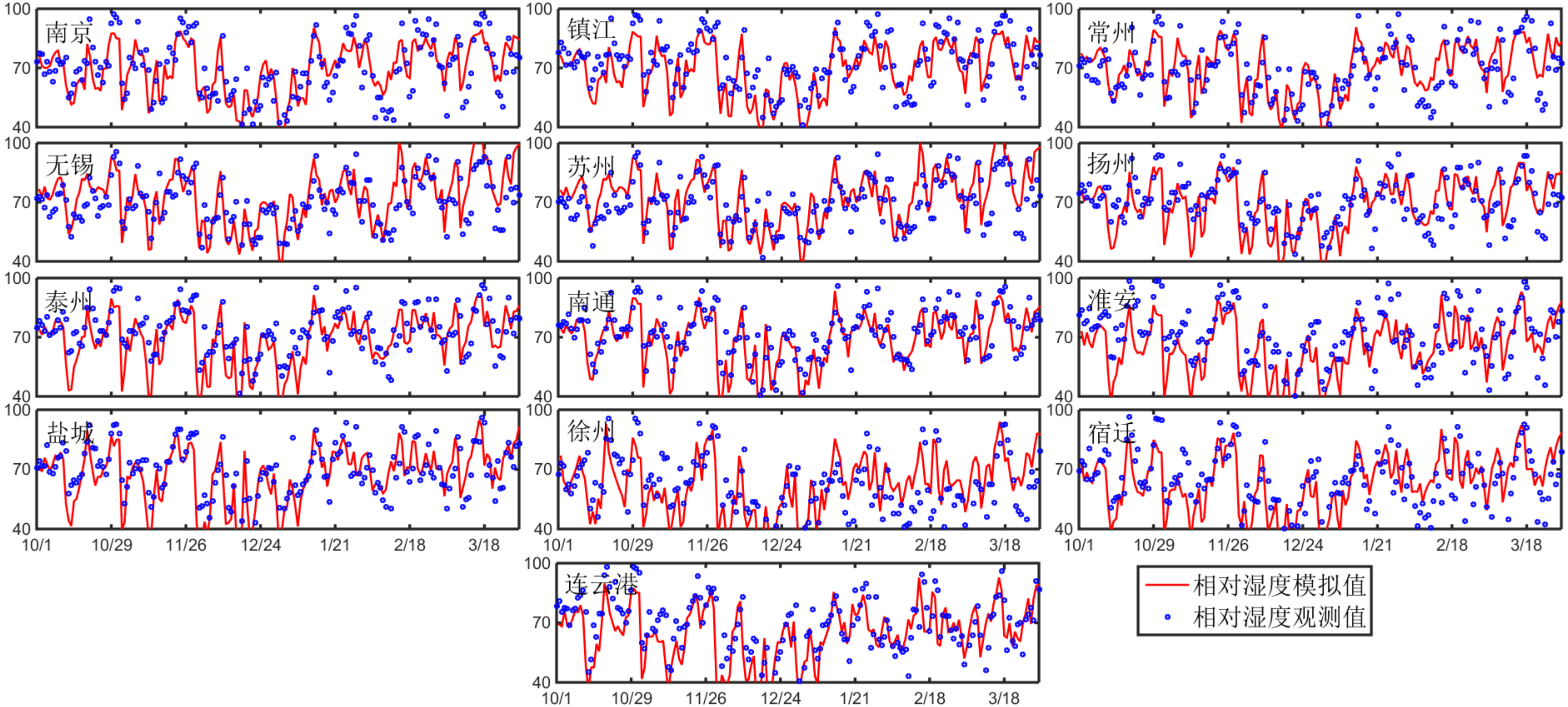

Fig. 4a Observations (blue spots) and simulations (red lines) of relative humidity at 13 cites in Jiangsu Province from Oct 2014 to Mar 2015.

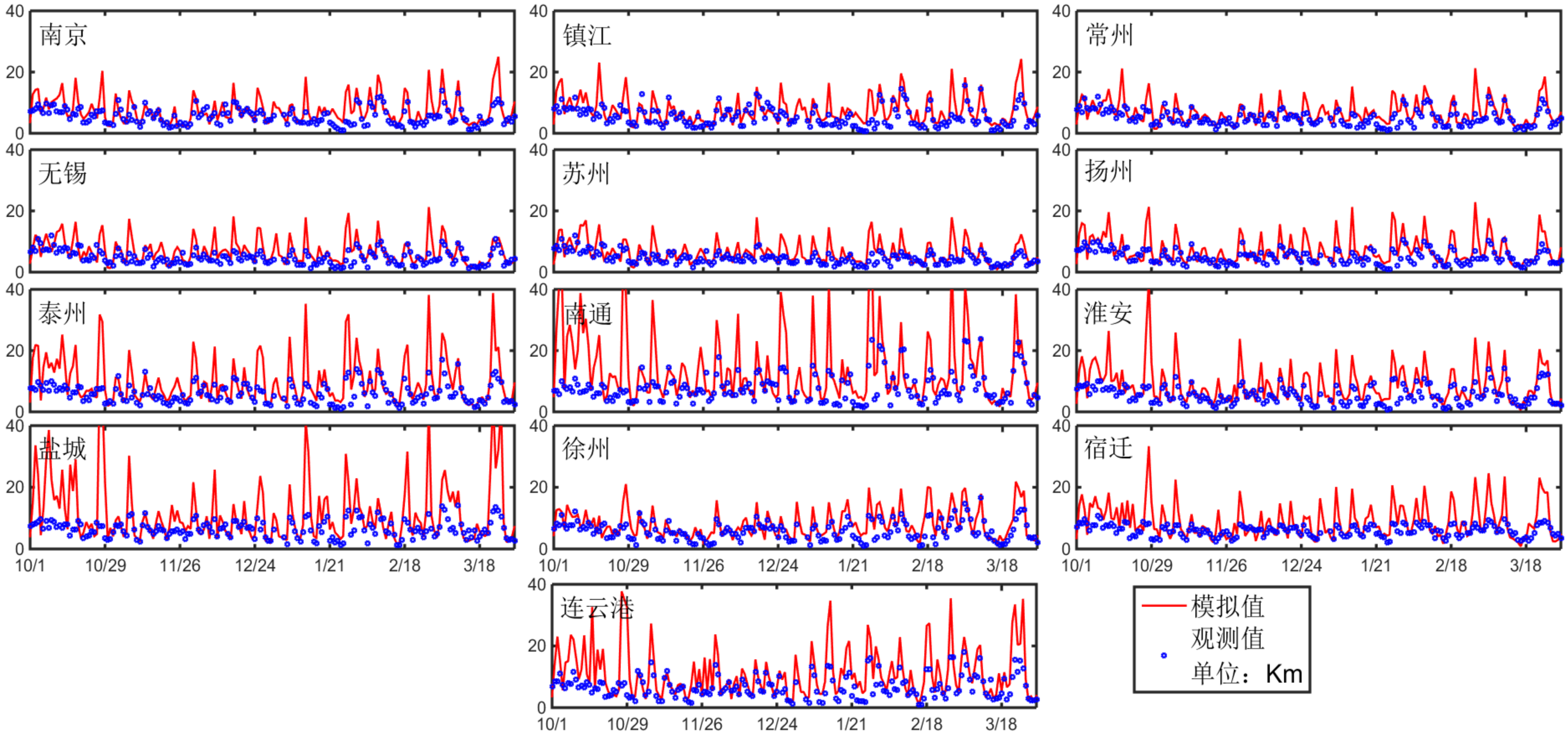

Fig. 4b Observations (blue spots) and simulations (red lines) of visibility at 13 cites in Jiangsu Province from Oct 2014 to Mar 2015.

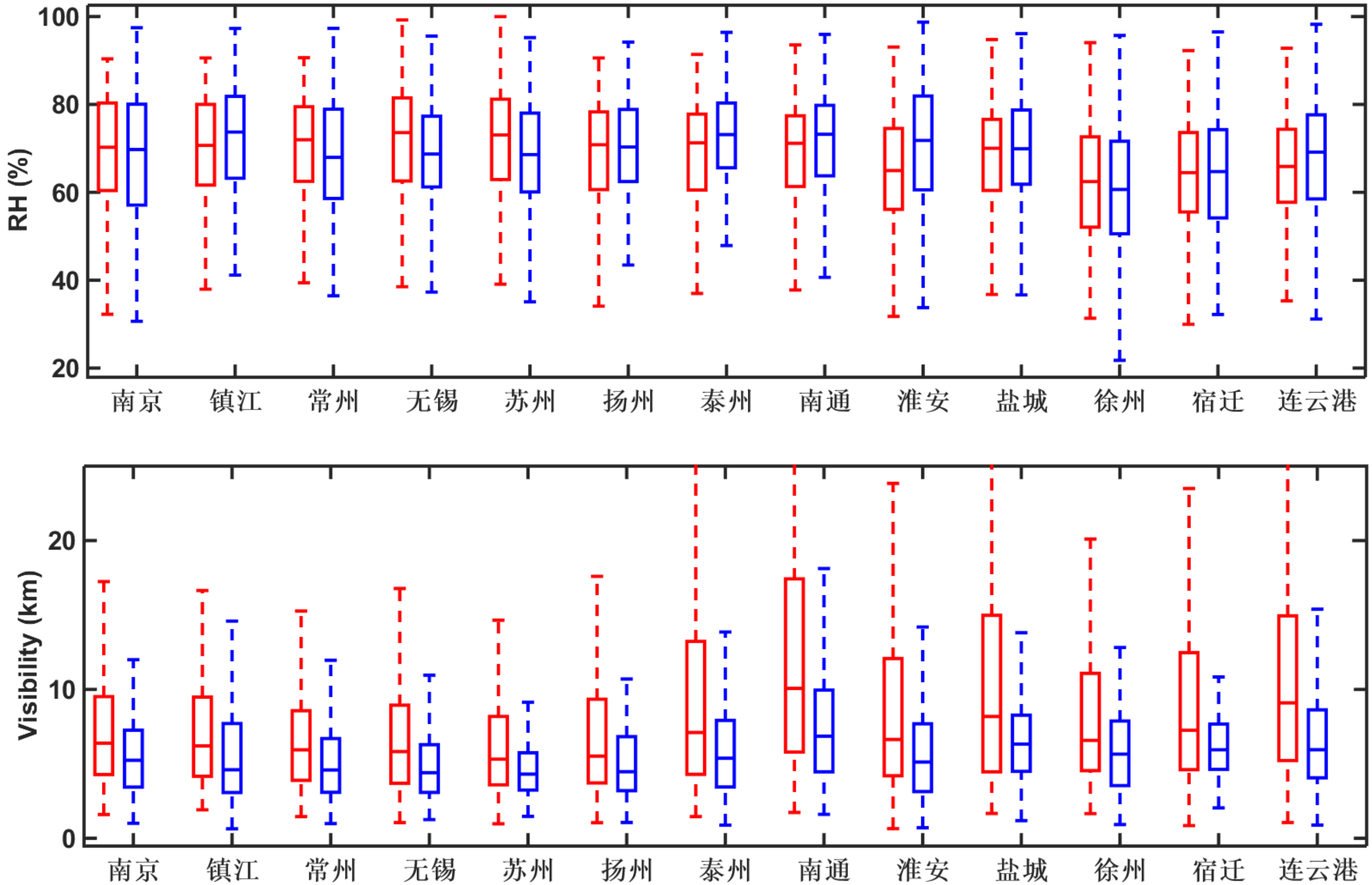

Fig. 5 Observations (blue) and simulations (red) of humidity and visibility boxplot at 13 cites in Jiangsu Province.

Table. 2 Correlation coefficient

	PM10		PM2.5		Relative Humidity		Visibility	
	R	RMSE	R	RMSE	R	RMSE	R	RMSE
南京	0. 37	57. 02	0. 40	47. 75	0. 70	11. 41	0. 64	4. 74
镇江	0. 47	53. 32	0. 52	38. 85	0. 72	10. 84	0. 64	6. 14
常州	0. 45	52. 58	0. 50	40. 15	0. 68	11. 09	0. 66	5. 96
无锡	0. 45	50. 81	0. 50	39. 98	0. 65	12. 08	0. 57	5. 65
苏州	0. 51	45. 99	0. 54	35. 46	0. 65	12. 09	0. 58	6. 26
扬州	0. 57	55. 88	0. 55	37. 36	0. 60	11. 62	0. 66	7. 20
泰州	0. 42	65. 25	0. 54	37. 95	0. 62	11. 94	0. 69	11. 67
南通	0. 54	61. 93	0. 57	40. 39	0. 67	10. 96	0. 58	12. 39
淮安	0. 50	64. 11	0. 53	39. 85	0. 59	13. 83	0. 64	11. 33
盐城	0. 45	72. 02	0. 53	41. 51	0. 63	12. 07	0. 60	19. 60
徐州	0. 47	73. 62	0. 52	40. 76	0. 45	15. 65	0. 71	6. 03
宿迁	0. 41	73. 53	0. 47	36. 81	0. 52	14. 18	0. 61	10. 09
连云港	0. 56	76. 26	0. 64	43. 10	0. 66	11. 74	0. 66	14. 11

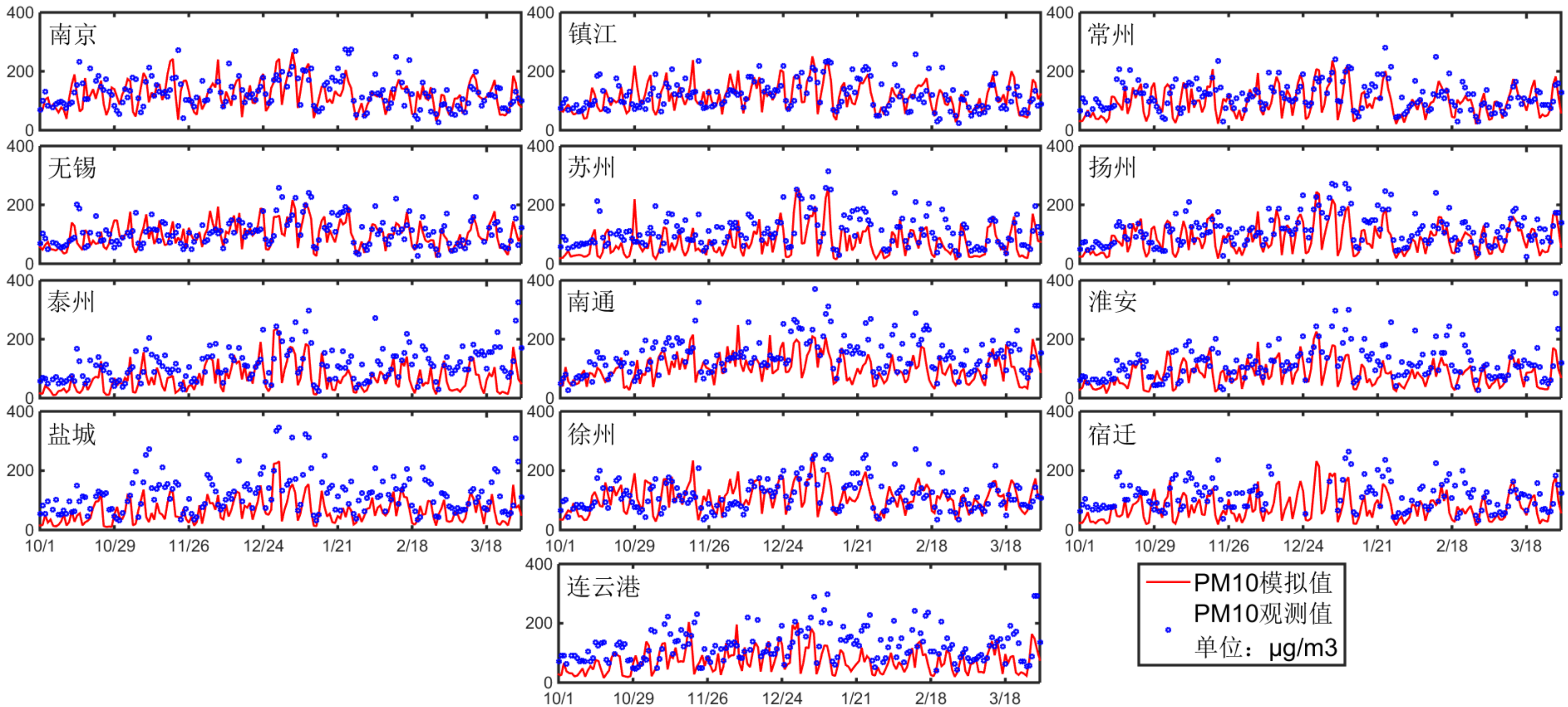

Fig. 6a Observations (blue spots) and simulations (red lines) of PM10 at 13 cites in Jiangsu Province from Oct 2014 to Mar 2015.

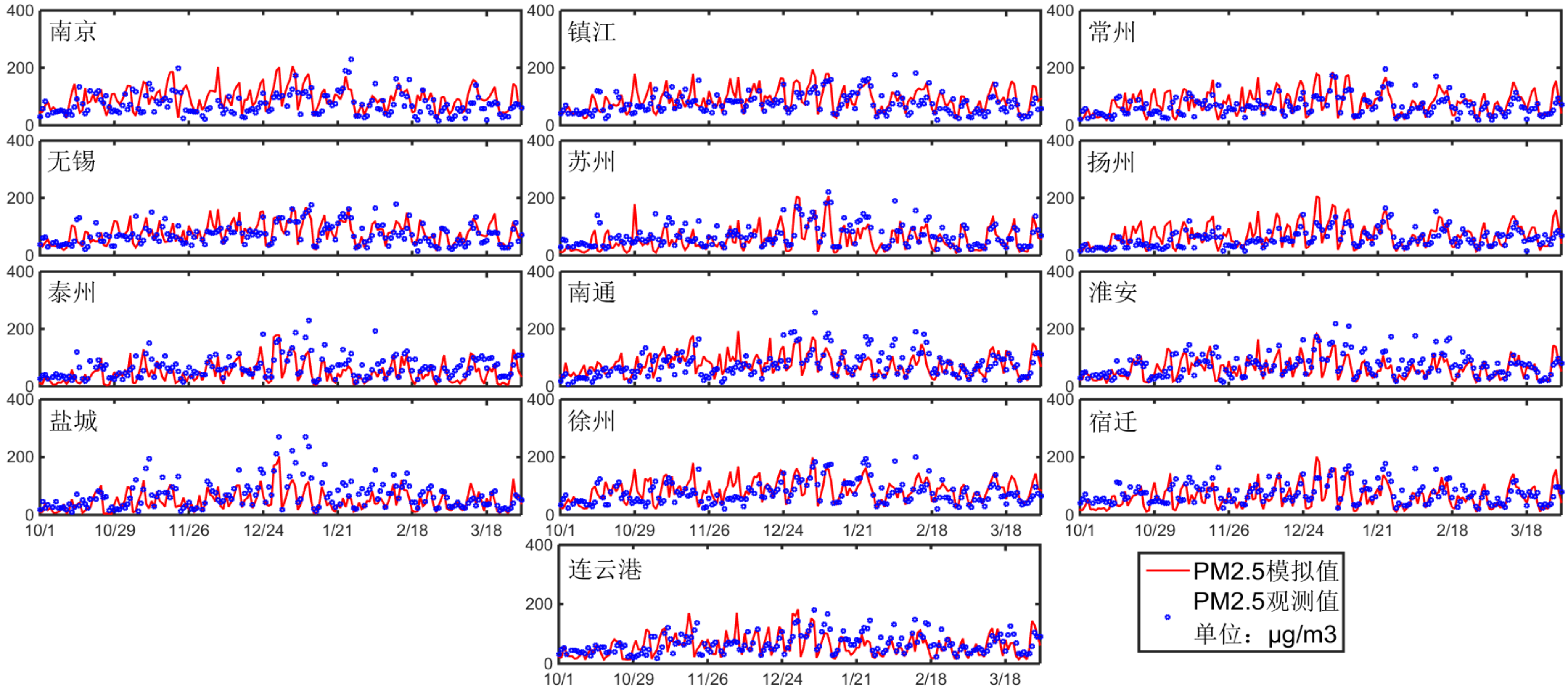

Fig. 6a Observations (blue spots) and simulations (red lines) of PM2.5 at 13 cites in Jiangsu Province from Oct 2014 to Mar 2015.

Table. 3 The statistics of haze days (the total period of 182 days in winter 2014 - 2015)

City	南京	镇江	常州	无锡	苏州	扬州	泰州	南通	淮安	盐城	徐州	宿迁	连云港
Obs	132	122	126	139	124	128	123	108	129	125	142	133	119
Mod	130	126	134	123	128	121	98	78	107	90	124	105	92

Discussions

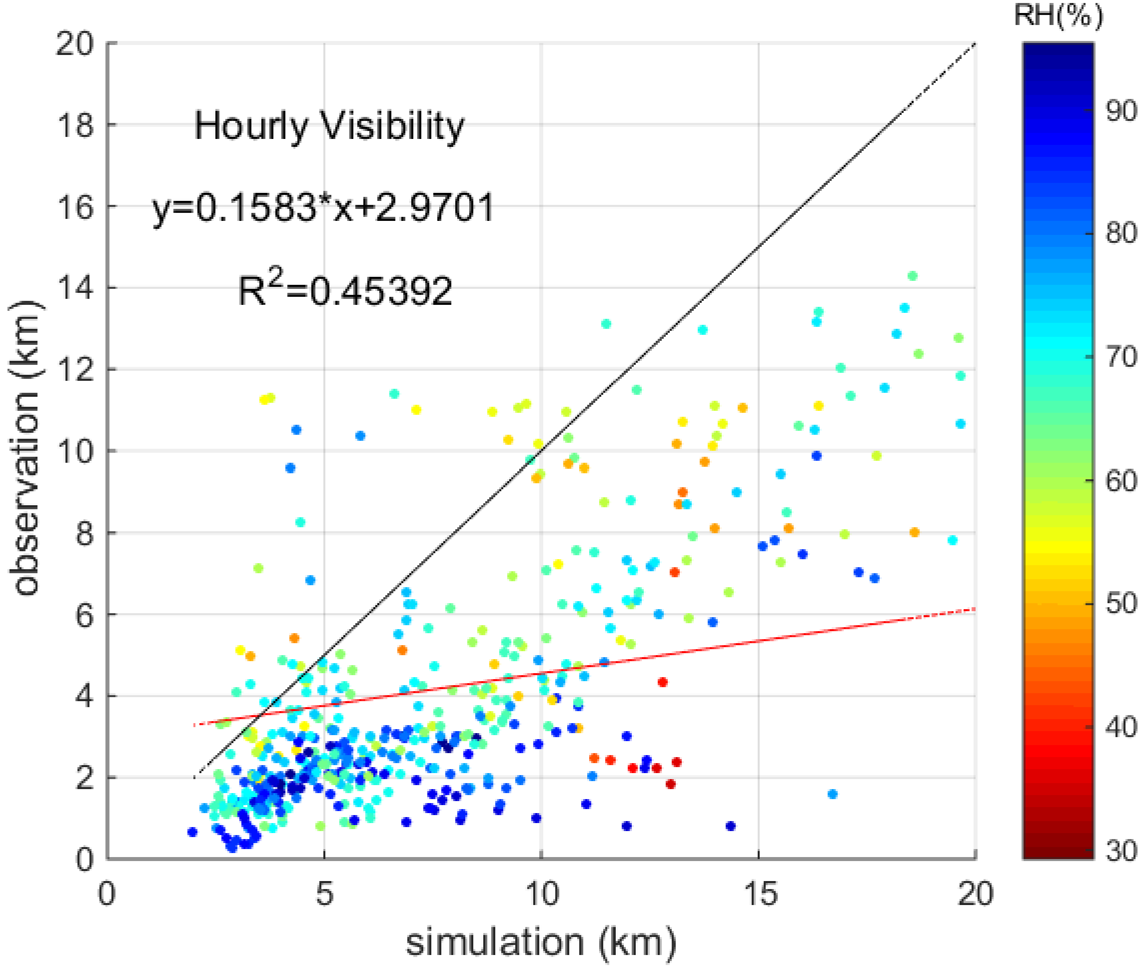

Fig. 7a Observations and simulations of visibility in Jiangsu Province from Oct 2014 to Mar 2015. Data points are color coded for relative humidity (RH)

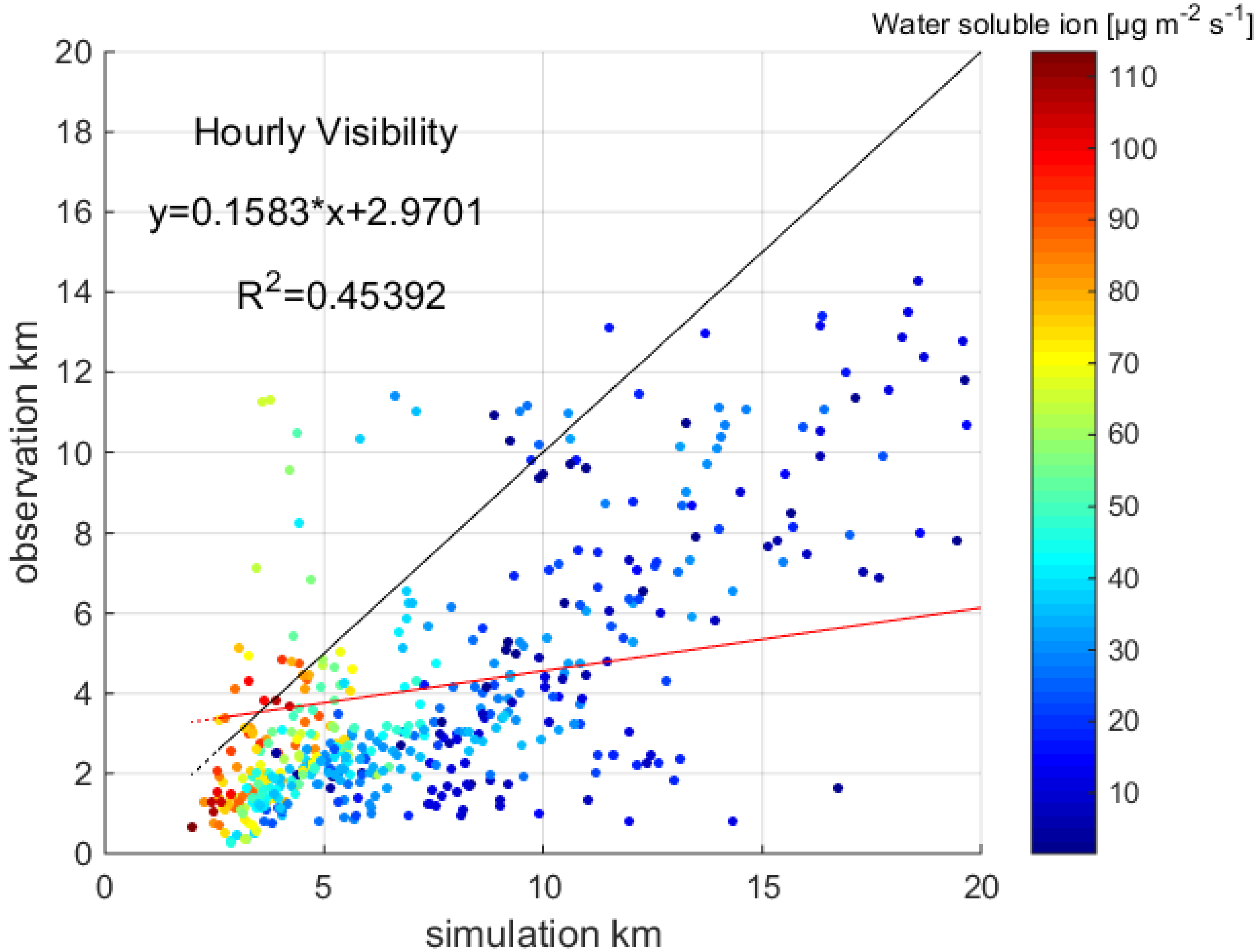

Fig. 7b Observations and simulations of visibility in Jiangsu Province from Oct 2014 to Mar 2015. Data points are color coded for water soluble ion.

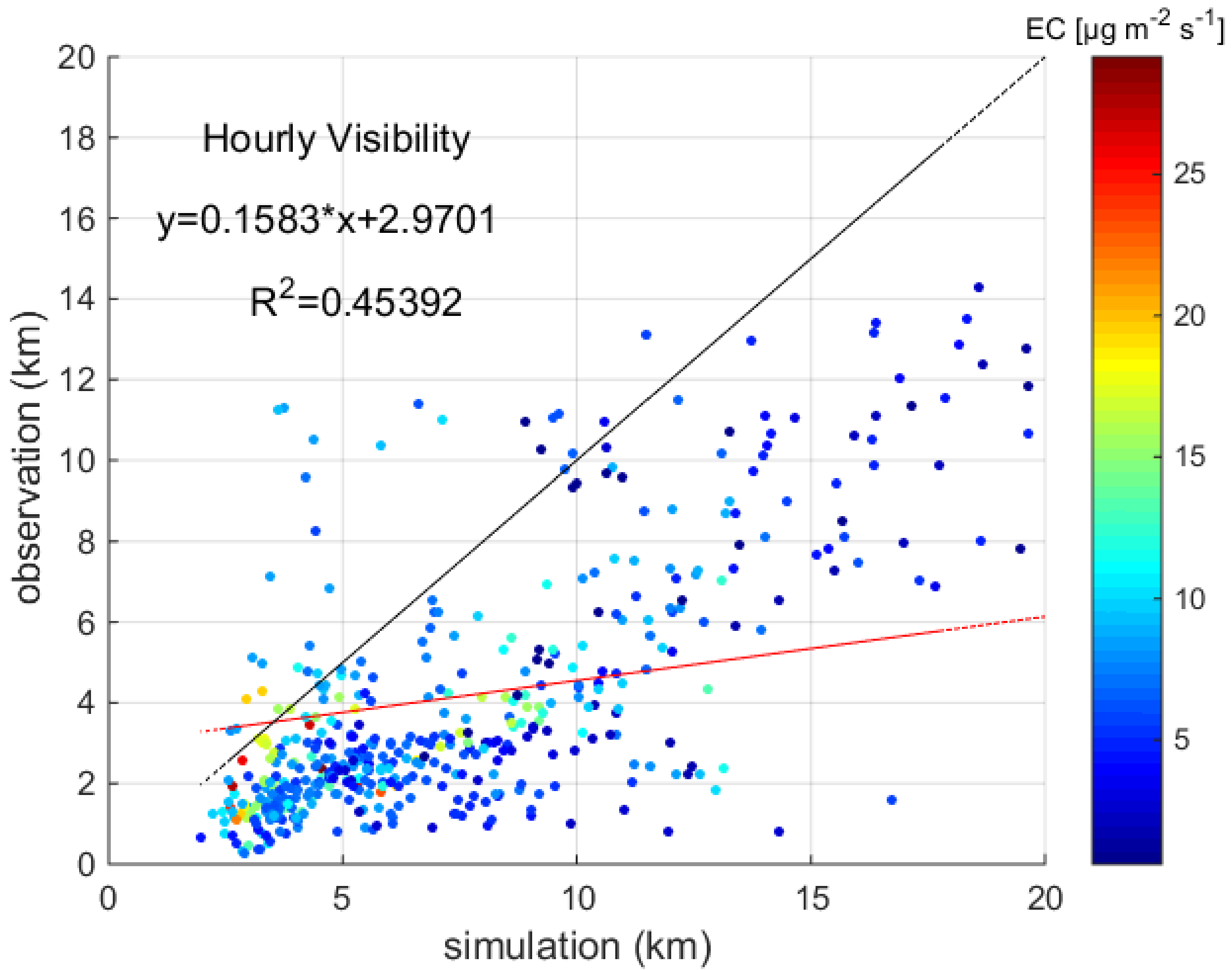

Fig. 7c Observations and simulations of visibility in Jiangsu Province from Oct 2014 to Mar 2015. Data points are color coded for EC.

Conclusions and next work

1）WRF/CMAQ model can simulate the pattern of relative humidity. Due to the accuracy of the model resolution is not high enough, some part of grids in coastal cities were treated as ocean area, the simulated relative humidity is underestimated.

2) The simulation of PM2.5 concentration is better than PM10, and its best correlation coefficient reaches 0.6.

3) Number of haze days calculated by simulation is always less than observation. In southern cities, its observation value and the simulation value of haze days were similar, and in cities which visibility simulation is larger, the simulation of haze days is underestimated.

4) Uncertainty of visibility prediction method should be discuss more.

THANK YOU