Supplement of

Top-down estimate of black carbon emissions for city cluster using ground observations: A case study in southern Jiangsu, China

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and Shanghai (c) for January of 2015.

Figure S9. The same as Figure S8 but for April of 2015.

Figure S10. The same as Figure S8 but for July of 2015.

Figure S11. The same as Figure S8 but for October of 2015.

Tables

Table S1. Data sources of activity levels and scaling factors for BC emissions from 2012 to 2015 by source categories in southern Jiangsu.

Sector	Subsector	Main sources of activity data	Scaling factor
Power generation		Jiangsu Statistical Yearbook	1.108
Industry	Iron and steel	China and Jiangsu Statistical Yearbook; China Energy and Industry Statistical Yearbook	1.302
	Nonmetal mineral production		1.074
	Nonferrous metal smelting		0.690
	Oil refinery		1.089
	Chemical industry		1.107
	Glass		0.716
	Other industry		1.020
Residential sources	Fossil fuel combustion	Jiangsu Energy Statistical Yearbook; Jiangsu Statistical Yearbook	1.106
	Biofuel		1.043
Transportation	On-road	Jiangsu Energy Statistical Yearbook; Jiangsu Statistical Yearbook	1.112
	Off-road		1.182

Table S2. Statistic indicators of meteorological parameters in the third domain for January (a), April (b), July (c) and October (d) in 2015.

Variable	Parameter	Lukou	Hongqiao	Liyang
T2	Average OBS (^{o}C)	4.63	6.81	5.40
	Average SIM (^{o}C)	5.28	5.89	5.70
	Bias (^{o}C)	0.64	-0.92	0.30
	NMB (%)	14.00%	-14.00%	5.00%
	NME (%)	30.00%	20.00%	22.00%
	RMSE (^{o}C)	1.78	1.80	1.61
	IOA	0.95	0.95	0.96
RH2	Average OBS (%)	74.14	66.99	70.97
	Average SIM (%)	73.24	75.52	71.63
	Bias (%)	-0.90	8.63	0.66
	NMB (%)	-1.00%	13.00%	1.00%
	NME (%)	17.00%	19.00%	19.00%
	RMSE (%)	16.89	15.78	17.49
	IOA	0.84	0.85	0.82
WS10	Average OBS (m/s)	2.34	3.90	1.98
	Average SIM (m/s)	3.20	3.68	3.47
	Bias (m/s)	0.86	-0.22	1.49
	NMB (%)	37.00%	-6.00%	76.00%
	NME (%)	52.00%	31.00%	83.00%
	RMSE (m/s)	1.50	1.52	2.02
	IOA	0.76	0.77	0.51
WD10	Average OBS (deg)	159.39	201.94	175.17
	Average SIM (deg)	162.71	190.50	172.29
	Bias (deg)	3.32	-11.44	-2.89
	NMB(%)	2.00%	-6.00%	-2.00%
	NME(%)	28.00%	28.00%	36.00%
	RMSE (deg)	85.02	116.00	116.03
	IOA	0.85	0.78	0.76

(a)

Variable	Parameter	Lukou	Hongqiao	Liyang
T2	Average OBS (^{o}C)	15.54	16.51	16.05
	Average SIM (^{o}C)	15.05	14.99	15.44
	Bias (^{o}C)	-0.49	-1.53	-0.59
	NMB (%)	-3.00%	-9.00%	-4.00%
	NME (%)	9.00%	12.00%	8.00%
	RMSE (^{o}C)	1.86	2.42	1.76
	IOA	0.97	0.95	0.98
RH2	Average OBS (%)	70.84	65.91	68.85
	Average SIM (%)	77.27	80.28	75.31
	Bias (%)	6.43	14.40	6.38
	NMB (%)	9.00%	22.00%	9.00%
	NME (%)	17.00%	23.00%	19.00%
	RMSE (%)	16.29	18.97	17.49
	IOA	0.85	0.79	0.82
WS10	Average OBS (m/s)	2.88	4.13	2.46
	Average SIM (m/s)	3.57	4.08	3.56
	Bias (m/s)	0.69	-0.05	1.31
	NMB (%)	24.00%	-1.00%	53.00%
	NME (%)	43.00%	24.00%	66.00%
	RMSE (m/s)	1.57	1.30	2.01
	IOA	0.81	0.87	0.68
WD10	Average OBS (deg)	159.28	182.74	145.96
	Average SIM (deg)	146.63	155.97	151.14
	Bias (deg)	-12.66	-26.77	5.18
	NMB(%)	-8.00%	-15.00%	4.00%
	NME(%)	35.00%	28.00%	36.00%
	RMSE (deg)	102.58	105.95	95.15
	IOA	0.74	0.75	0.77

(b)

Variable	Parameter	Lukou	Hongqiao	Liyang
	Average OBS (^{o}C)	26.51	27.31	26.74
	Average SIM (^{o}C)	25.20	25.28	25.22
	Bias (^{o}C)	-1.23	-1.88	-1.41
T2	NMB (%)	-5.00%	-7.00%	-5.00%
	NME (%)	6.00%	8.00%	7.00%
	RMSE (^{o}C)	1.97	2.72	2.19
	IOA	0.92	0.89	0.92
	Average OBS (%)	83.92	77.01	79.34
	Average SIM (%)	86.57	85.49	85.50
	Bias (%)	2.34	7.78	5.63
RH2	NMB (%)	3.00%	10.00%	7.00%
	NME (%)	7.00%	14.00%	10.00%
	RMSE (%)	8.04	13.28	9.64
	IOA	0.90	0.77	0.86
	Average OBS (m/s)	2.76	3.91	1.97
	Average SIM (m/s)	2.89	3.24	2.95
	Bias (m/s)	0.13	-0.62	0.97
WS10	NMB (%)	5.00%	-16.00%	50.00%
	NME (%)	38.00%	29.00%	65.00%
	RMSE (m/s)	1.34	1.42	1.65
	IOA	0.76	0.88	0.65
	Average OBS (deg)	144.66	143.00	142.43
	Average SIM (deg)	131.51	127.30	134.01
	Bias (deg)	-12.67	-15.50	-8.36
WD10	NMB(%)	-9.00%	-11.00%	-6.00%
	NME(%)	28.00%	27.00%	28.00%
	RMSE (deg)	73.74	77.58	74.94
	IOA	0.79	0.76	0.79

(c)

Variable	Parameter	Lukou	Hongqiao	Liyang
	Average OBS (^{o}C)	17.97	20.13	18.46
	Average SIM (^{o}C)	18.69	18.72	18.80
	Bias (^{o}C)	0.70	-1.42	0.32
T2	NMB (%)	4.00%	-7.00%	2.00%
	NME (%)	8.00%	8.00%	6.00%
	RMSE (^{o}C)	1.72	2.10	1.36
	IOA	0.95	0.90	0.96
	Average OBS (%)	77.67	68.84	75.70
	Average SIM (%)	67.74	76.94	70.72
	Bias (%)	-9.58	8.00	-4.62
RH2	NMB (%)	-12.00%	12.00%	-6.00%
	NME (%)	17.00%	15.00%	13.00%
	RMSE (%)	18.35	12.71	13.53
	IOA	0.82	0.87	0.88
	Average OBS (m/s)	2.43	3.24	1.81
	Average SIM (m/s)	2.92	2.84	3.11
	Bias (m/s)	0.51	-0.37	1.27
WS10	NMB (%)	21.00%	-11.00%	70.00%
	NME (%)	45.00%	34.00%	82.00%
	RMSE (m/s)	1.40	1.44	1.90
	IOA	0.74	0.74	0.55
	Average OBS (deg)	149.11	152.48	131.42
	Average SIM (deg)	134.04	134.22	138.19
	Bias (deg)	-15.43	-14.32	8.64
WD10	NMB(%)	-10.00%	-9.00%	7.00%
	NME(%)	30.00%	27.00%	28.00%
	RMSE (deg)	83.86	80.38	63.01
	IOA	0.80	0.83	0.85

(d)

Note: OBS and SIM indicated the results from observation and simulation, respectively. The Bias, NMB, NME, RMSE and IOA were calculated using following equations (P and O indicated the results from modeling prediction and observation, respectively):

$$Bias = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i);$$

$$NMB = \frac{\sum_{i=1}^{n}(P_i - O_i)}{\sum_{i=1}^{n} O_i} \times 100\%;$$

$$NME = \frac{\sum_{i=1}^{n}|P_i - O_i|}{\sum_{i=1}^{n} O_i} \times 100\%;$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)^2};$$

$$IOA = 1 - \frac{\sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(|P_i - \overline{O}| + |O_i - \overline{O}|)^2}$$

Table S3. The monthly and annual contributions of industry, power generation, residential resources and transportation to ambient BC concentrations at NJU and PAES.

Period	Site	Industry %	Power generation%	Residential resources%	Transportation %
January	NJU	11.48	0.53	11.72	11.27
	PAES	12.78	0.25	13.17	13.31
April	NJU	25.22	0.53	16.97	21.33
	PAES	25.26	0.21	19.54	24.23
July	NJU	29.73	0.62	20.16	32.27
	PAES	27.05	0.35	23.61	35.43
October	NJU	24.31	0.99	13.55	19.96
	PAES	23.58	0.57	16.14	23.32
Annual	NJU	21.01	0.68	14.71	19.21
	PAES	21.91	0.34	17.84	23.53

Table S4. The monthly emissions, simulated wet depositions and the ratios of wet deposition to emissions at NJU (a), PAES (b) and southern Jiangsu (c) using JS-prior and JS-posterior, respectively.

	January		April		July		October	
	JS-prior	JS-posterior	JS-prior	JS-posterior	JS-prior	JS-posterior	JS-prior	JS-posterior
Emission /kg	410.84	383.01	379.81	225.56	417.61	203.25	368.48	347.25
Wet deposition /kg	100.97	93.81	172.97	169.79	254.33	194.64	91.62	85.88
Wet deposition/emissions	24.58%	24.49%	45.54%	75.27%	60.90%	95.77%	24.86%	24.73%

(a)

	January		April		July		October	
	JS-prior	JS-posterior	JS-prior	JS-posterior	JS-prior	JS-posterior	JS-prior	JS-posterior
Emission /kg	1221.70	1286.89	1145.83	698.33	1130.99	528.42	1103.29	1219.42
Wet deposition /kg	109.27	105.10	186.10	183.60	189.71	146.10	51.03	50.00
Wet deposition/emissions	8.94%	8.17%	16.24%	26.29%	16.77%	27.65%	4.63%	4.10%

(b)

	January		April		July		October	
	JS-prior	JS-posterior	JS-prior	JS-posterior	JS-prior	JS-posterior	JS-prior	JS-posterior
Emission /Gg	2.26	1.45	2.10	0.78	2.26	0.90	2.38	1.33
Wet deposition /Gg	0.54	0.48	0.59	0.53	0.71	0.58	0.41	0.37
Wet deposition/emissions	24.06%	33.36%	27.96%	67.58%	31.26%	64.26%	17.24%	27.85%

(c)

Figures

Figure S1.

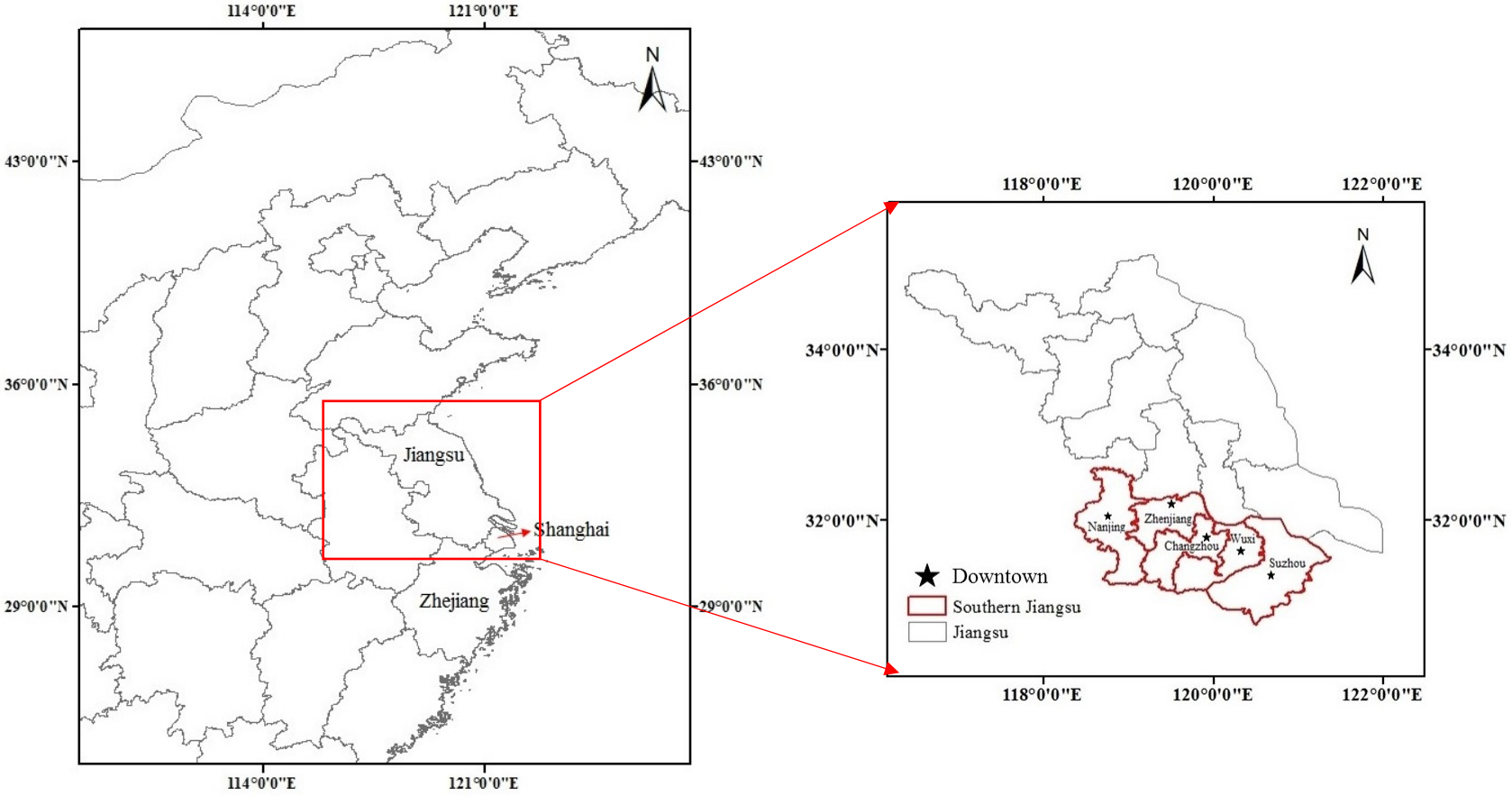
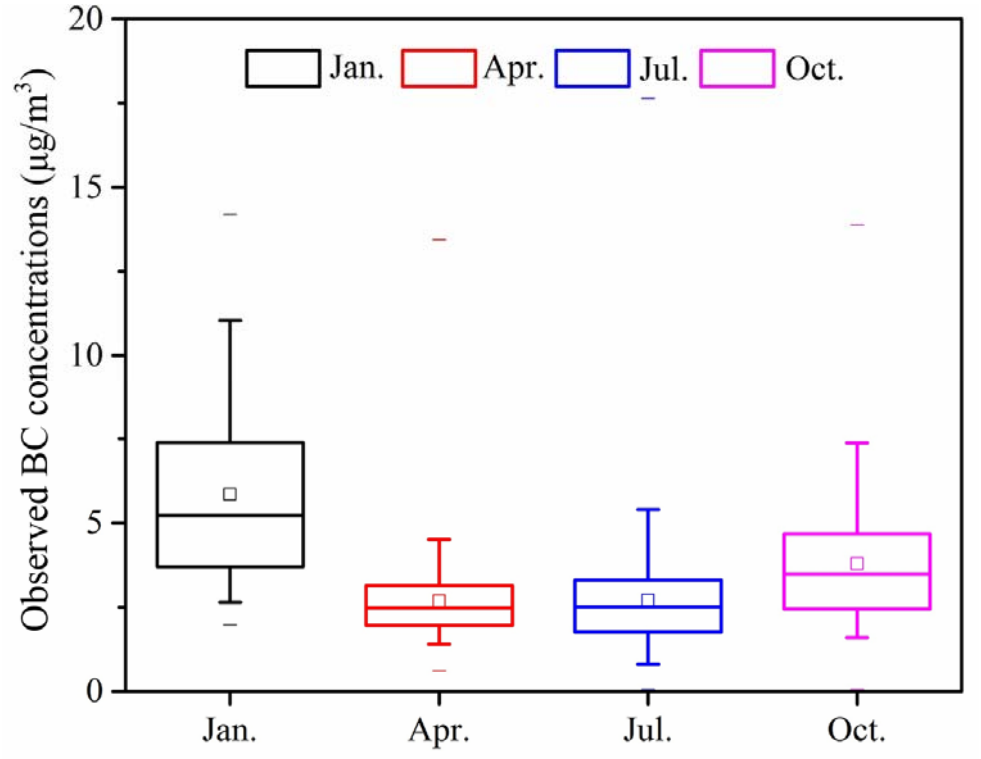
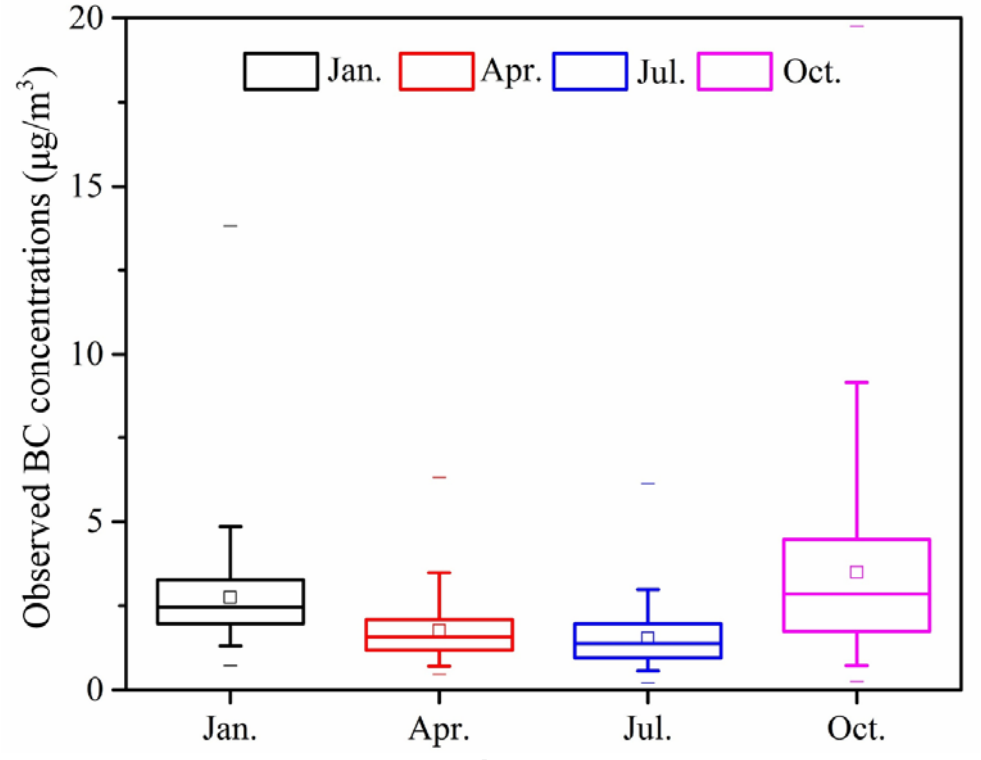


Figure S2.

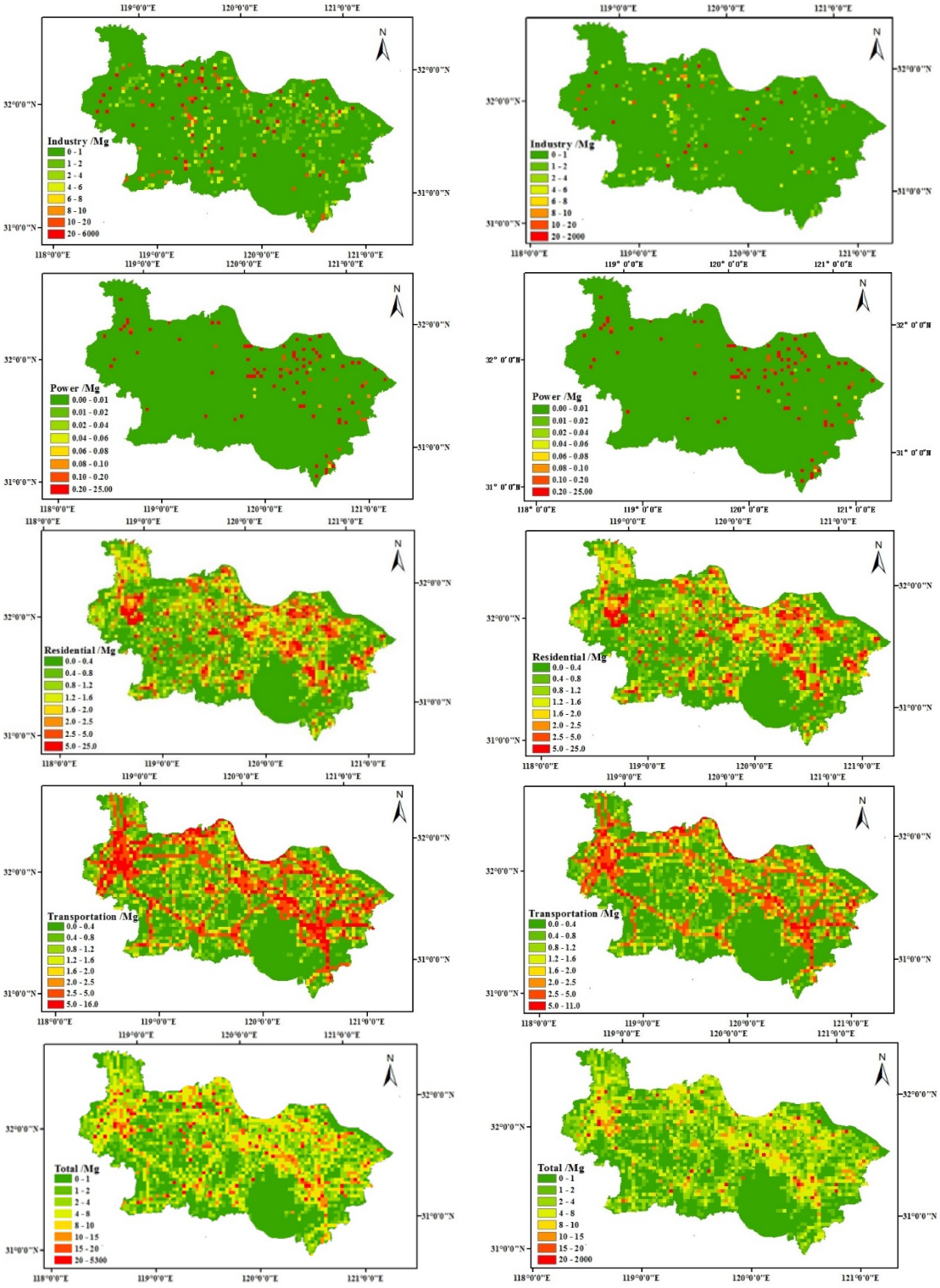

Jan.
Apr.
Jul.
Oct.
Observed BC concentrations (μg/m3)
0
5
10
15
20
Jan.
Apr.
Jul.
Oct.

(a)


Jan.
Apr.
Jul.
Oct.
Observed BC concentrations (μg/m3)
0
5
10
15
20
Jan.
Apr.
Jul.
Oct.

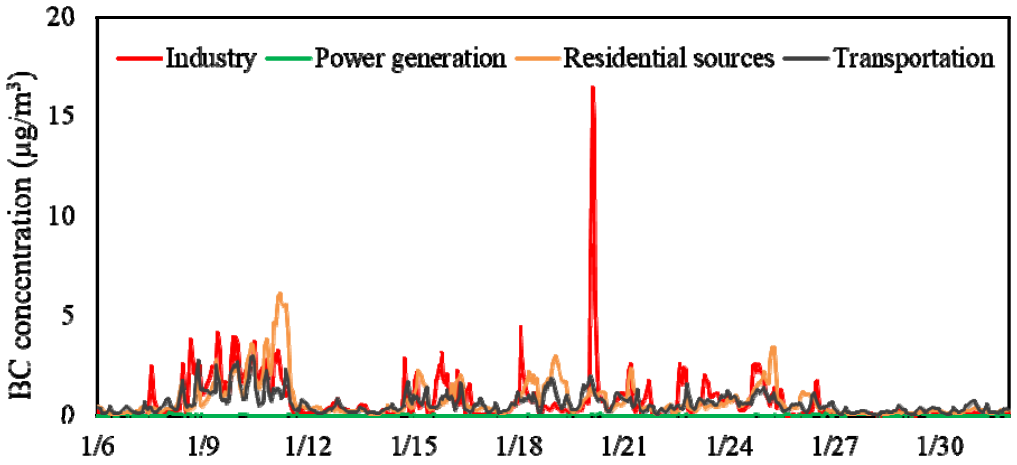
(b)

Figure S3.

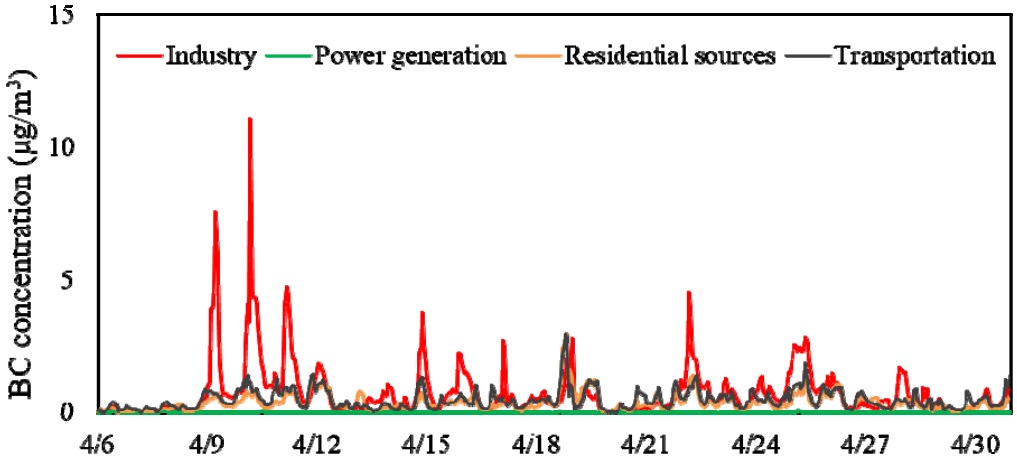

Industry /Mg
0 - 1
1 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 20
20 - 6000
Power /Mg
0.00 - 0.01
0.01 - 0.02
0.02 - 0.04
0.04 - 0.06
0.06 - 0.08
0.08 - 0.10
0.10 - 0.20
0.20 - 25.00
Residential /Mg
0.0 - 0.4
0.4 - 0.8
0.8 - 1.2
1.2 - 1.6
1.6 - 2.0
2.0 - 2.5
2.5 - 5.0
5.0 - 25.0
Transportation /Mg
0.0 - 0.4
0.4 - 0.8
0.8 - 1.2
1.2 - 1.6
1.6 - 2.0
2.0 - 2.5
2.5 - 5.0
5.0 - 16.0
Total /Mg
0 - 1
1 - 2
2 - 4
4 - 8
8 - 10
10 - 15
15 - 20
20 - 5300
Industry /Mg
0 - 1
1 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 20
20 - 2000
Power /Mg
0.00 - 0.01
0.01 - 0.02
0.02 - 0.04
0.04 - 0.06
0.06 - 0.08
0.08 - 0.10
0.10 - 0.20
0.20 - 25.00
Residential /Mg
0.0 - 0.4
0.4 - 0.8
0.8 - 1.2
1.2 - 1.6
1.6 - 2.0
2.0 - 2.5
2.5 - 5.0
5.0 - 25.0
Transportation /Mg
0.0 - 0.4
0.4 - 0.8
0.8 - 1.2
1.2 - 1.6
1.6 - 2.0
2.0 - 2.5
2.5 - 5.0
5.0 - 11.0
Total /Mg
0 - 1
1 - 2
2 - 4
4 - 8
8 - 10
10 - 15
15 - 20
20 - 2000

(a) (b)

Figure S4.



(a)



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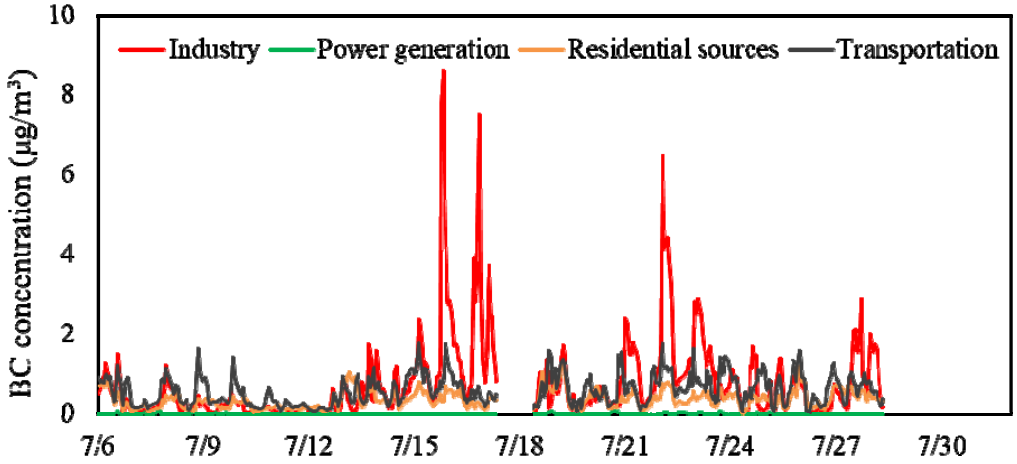
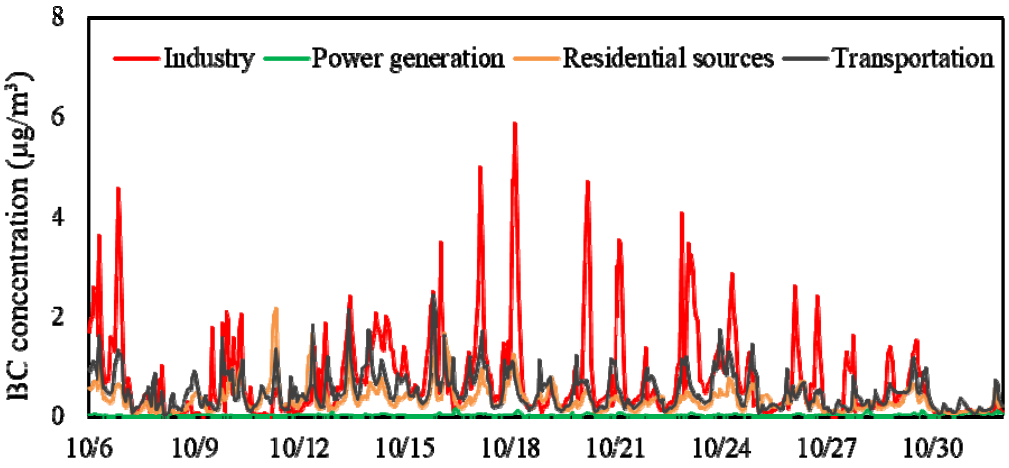
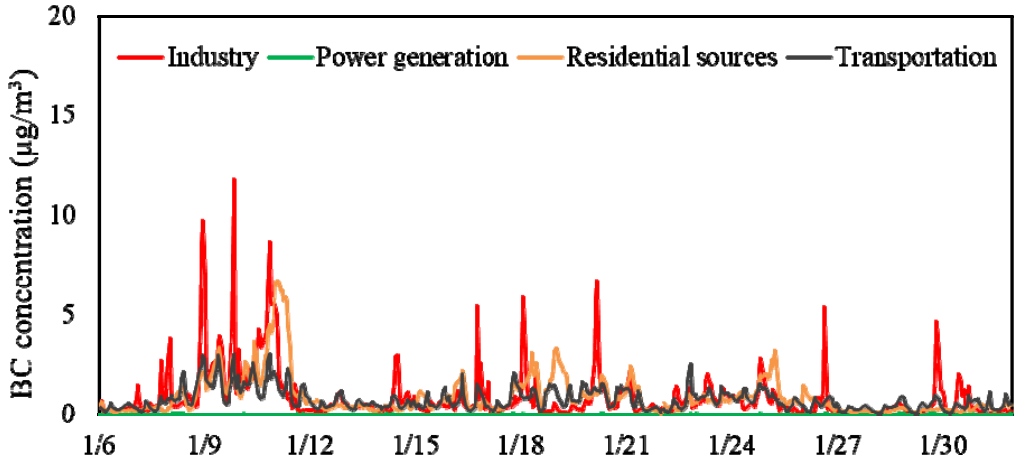


(c)

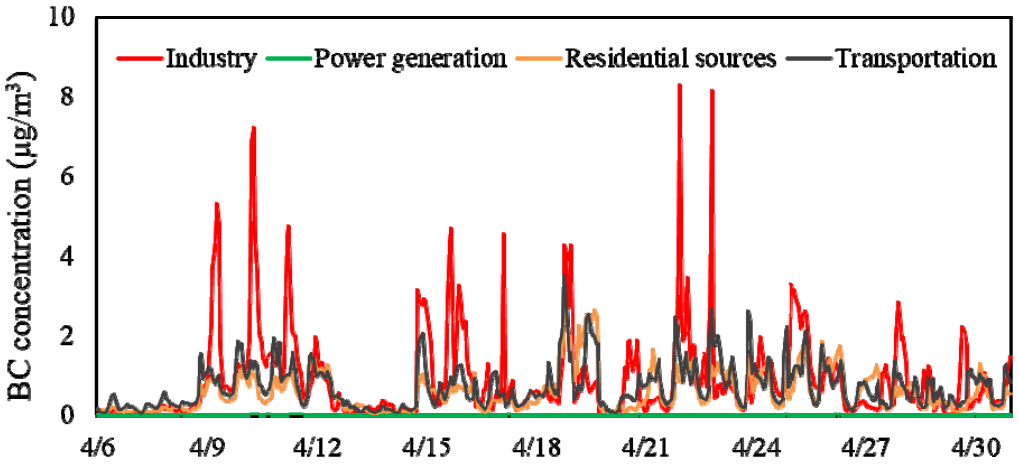

Industry
Power generation
Residential sources
Transportation
BC concentration (μg/m³)
8
6
4
2
0
10/6
10/9
10/12
10/15
10/18
10/21
10/24
10/27
10/30

(d)

Figure S5.



(a)



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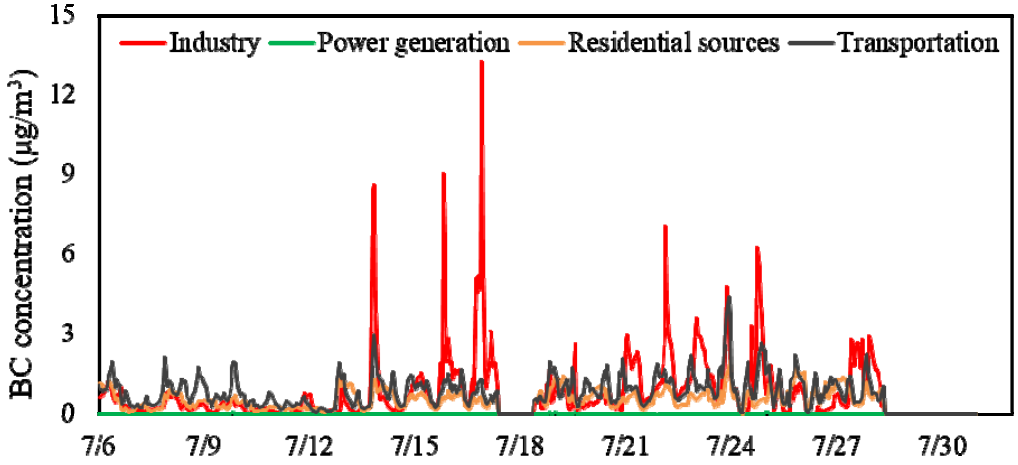

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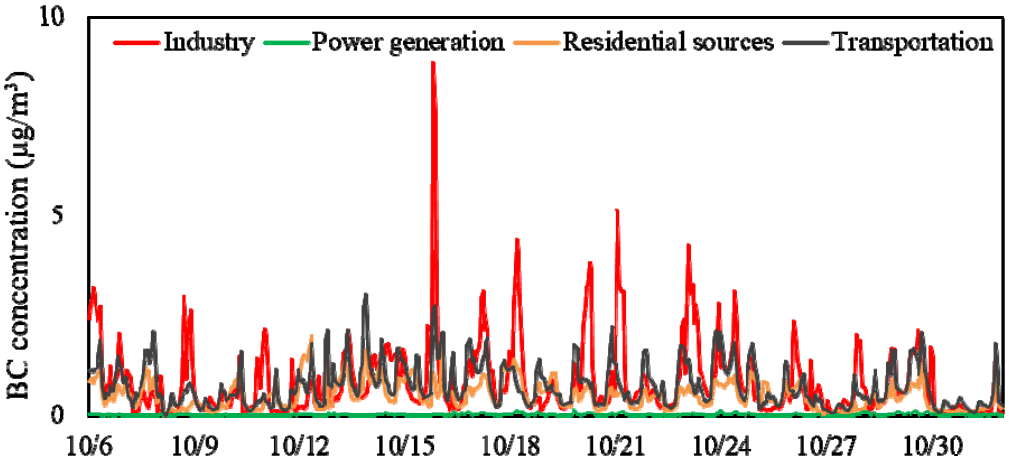

Industry
Power generation
Residential sources
Transportation
BC concentration (μg/m³)
10
5
0
10/6
10/9
10/12
10/15
10/18
10/21
10/24
10/27
10/30

(d)

Figure S6.

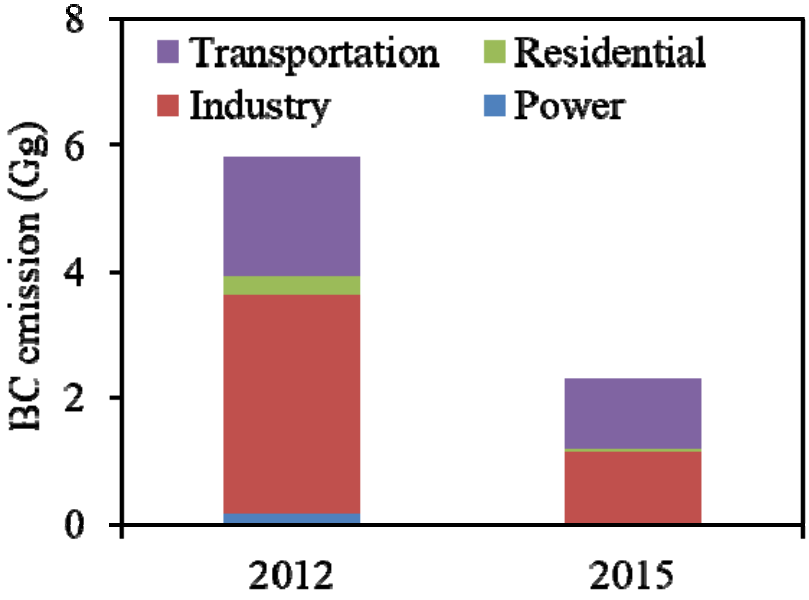

8
6
4
2
0
BC emission (Gg)
Transportation
Residential
Industry
Power
2012
2015

Figure S7.

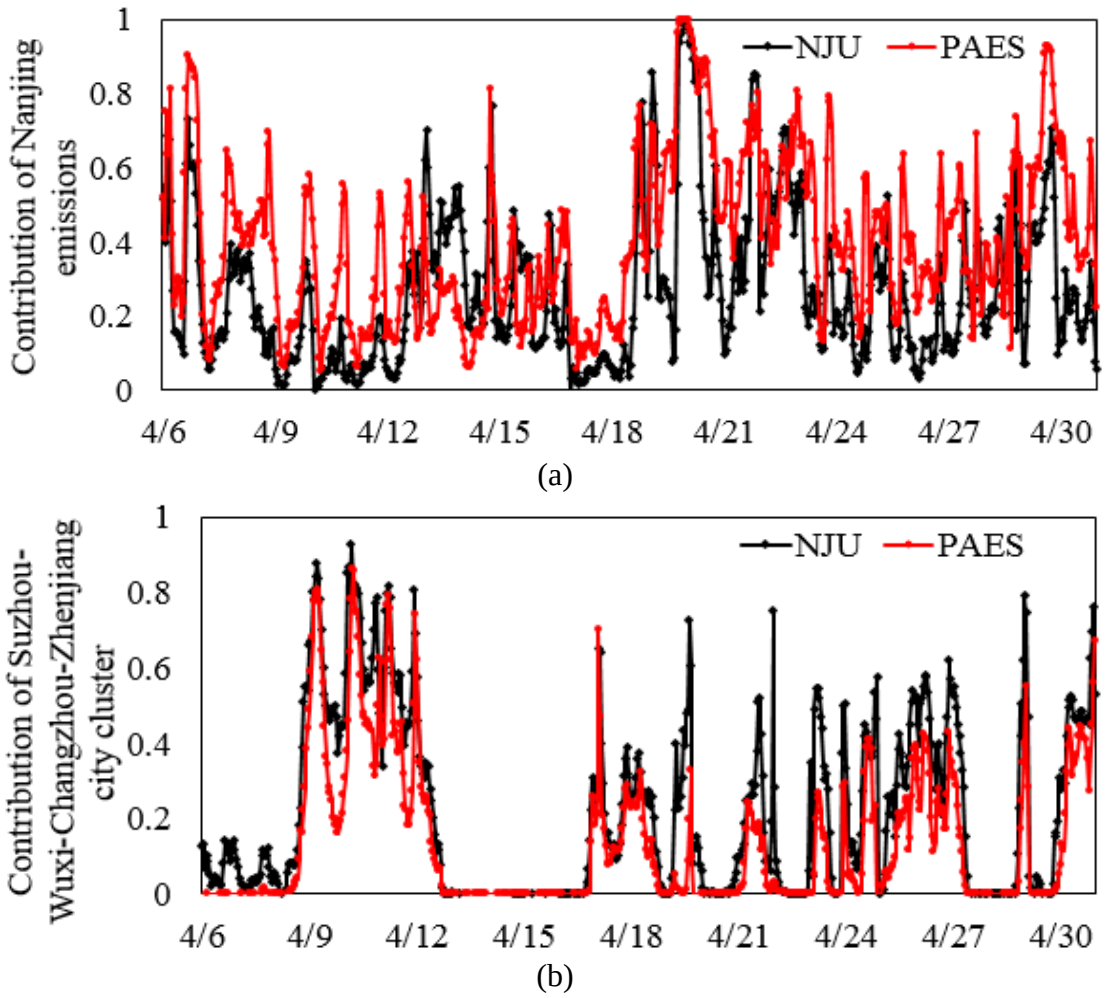
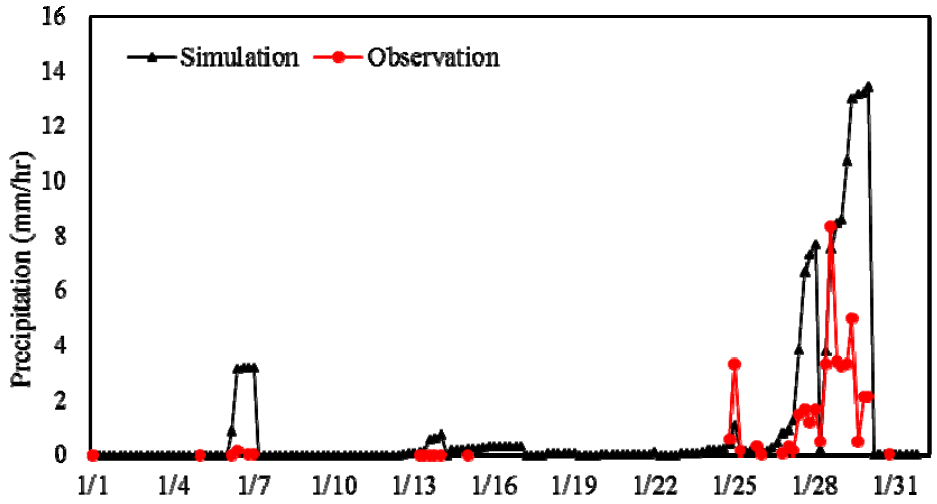
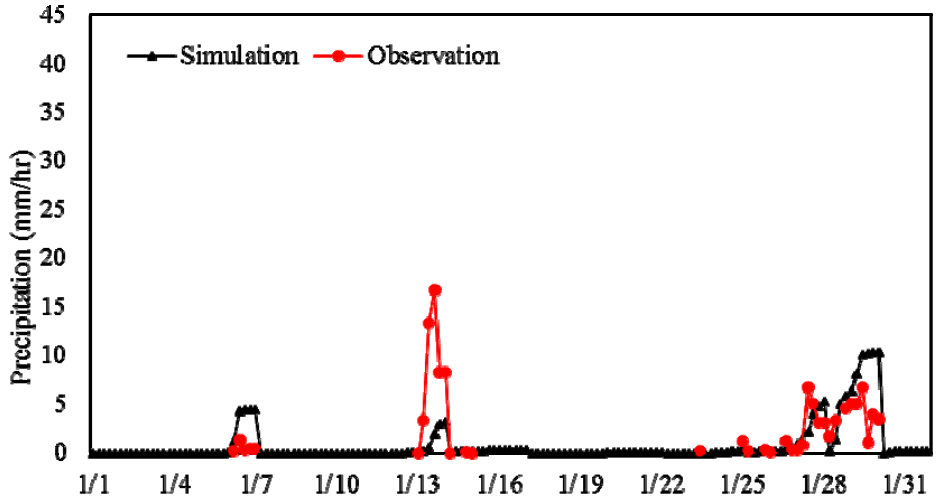

Contribution of Nanjing emissions
1
0.8
0.6
0.4
0.2
0
NJU
PAES
4/6
4/9
4/12
4/15
4/18
4/21
4/24
4/27
4/30
(a)
Contribution of Suzhou-Wuxi-Changzhou-Zhenjiang city cluster
1
0.8
0.6
0.4
0.2
0
NJU
PAES
4/6
4/9
4/12
4/15
4/18
4/21
4/24
4/27
4/30
(b)

Figure S8.



(a)



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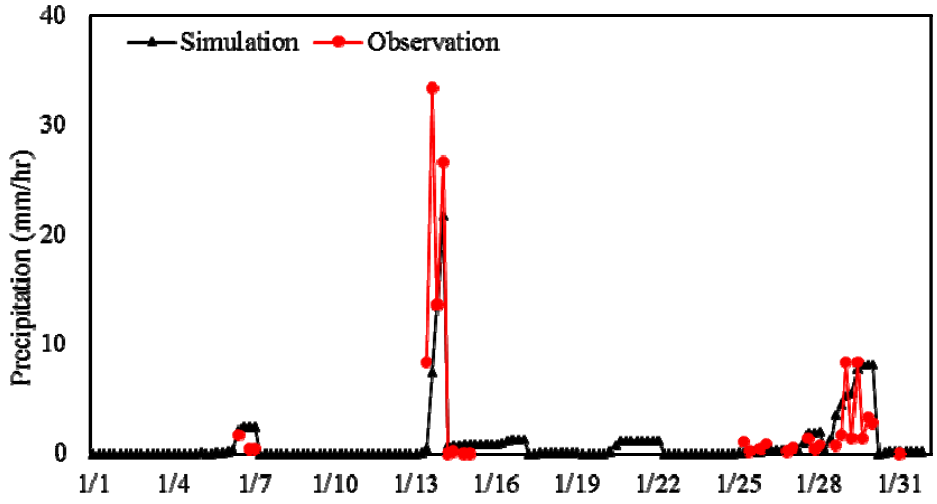
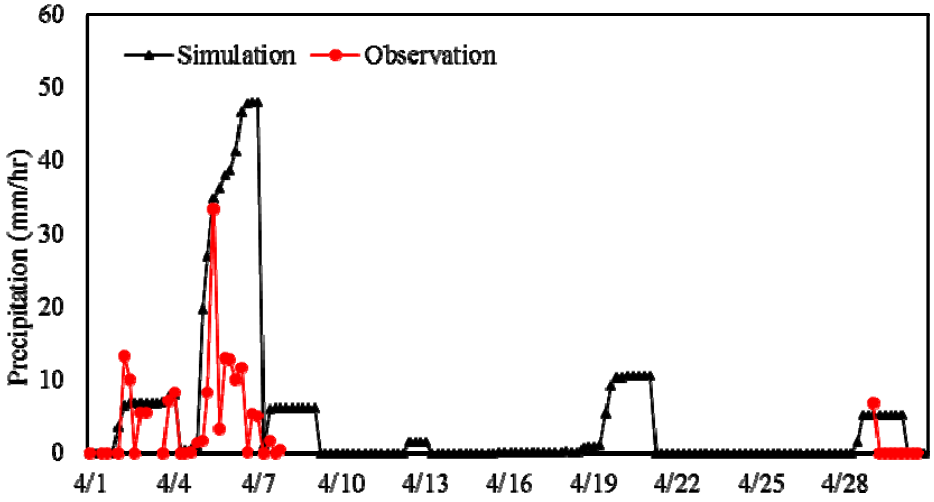
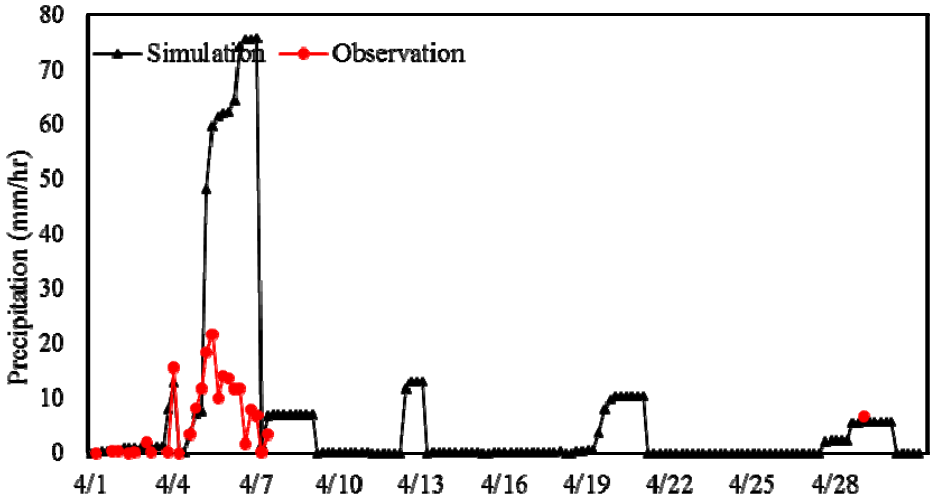


(c)

Figure S9.



(a)



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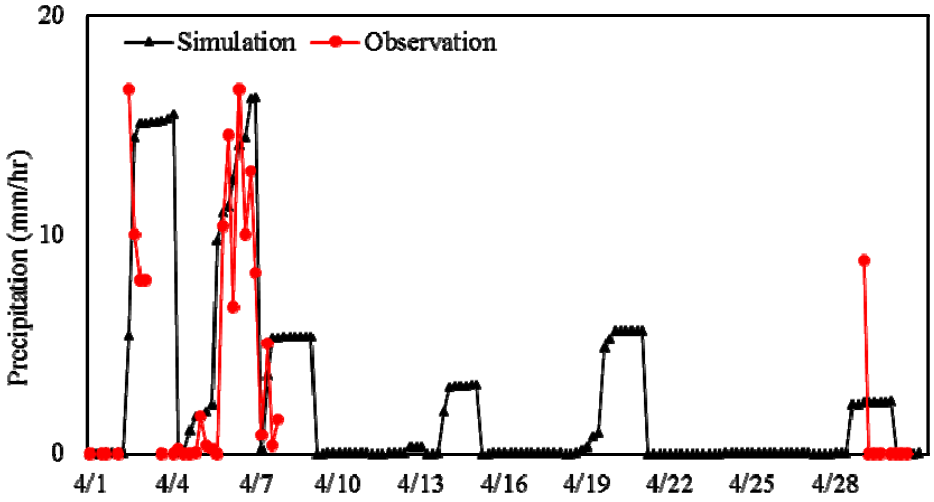
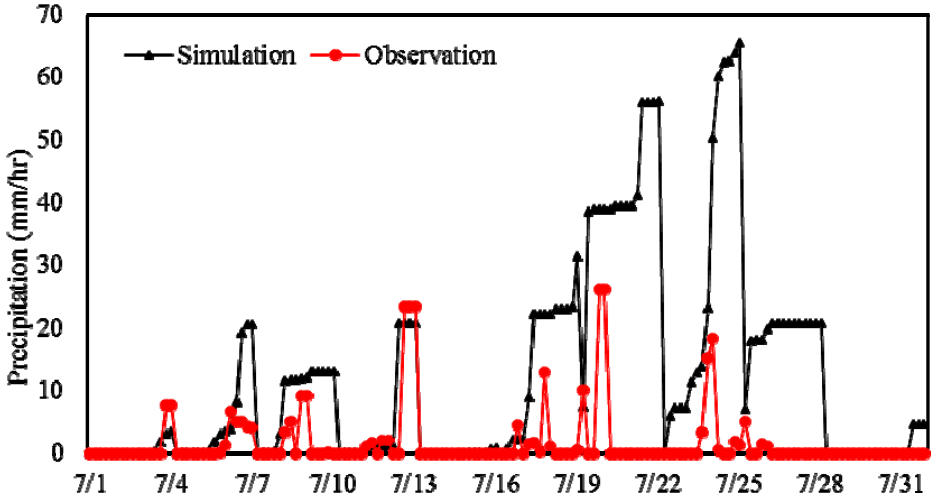
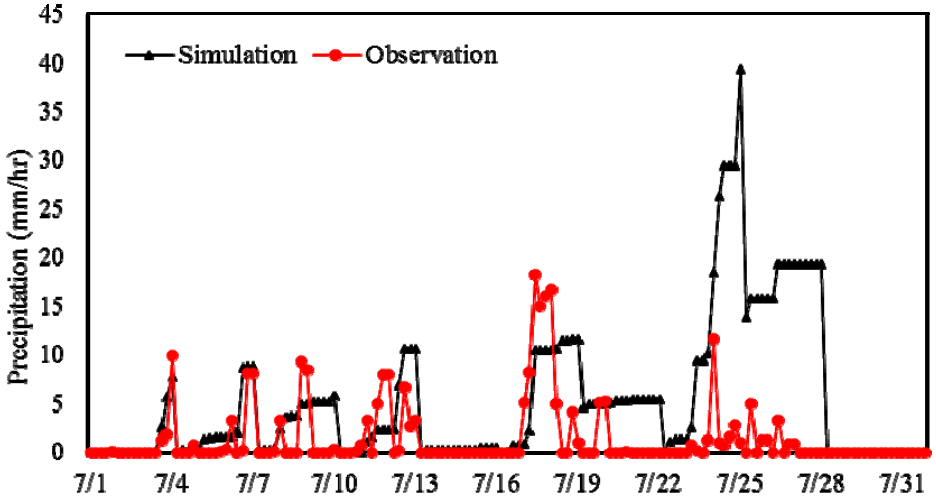


(c)

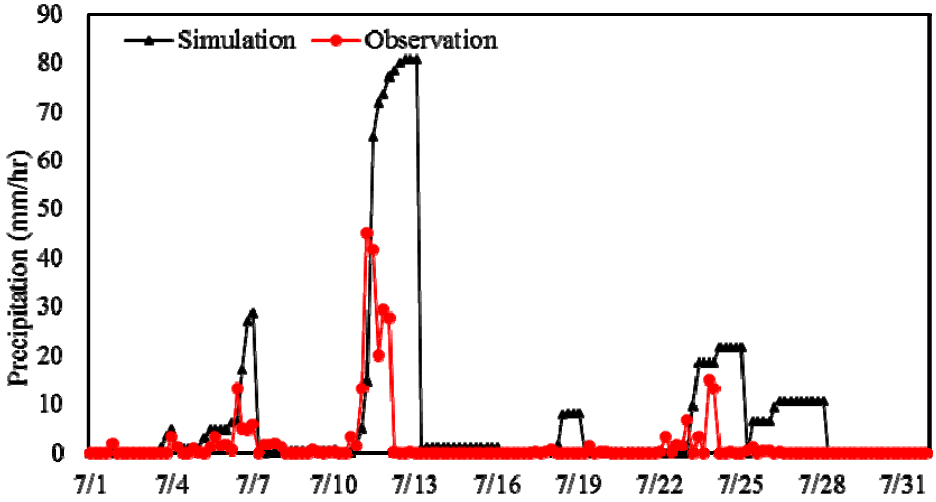
Figure S10.



(a)

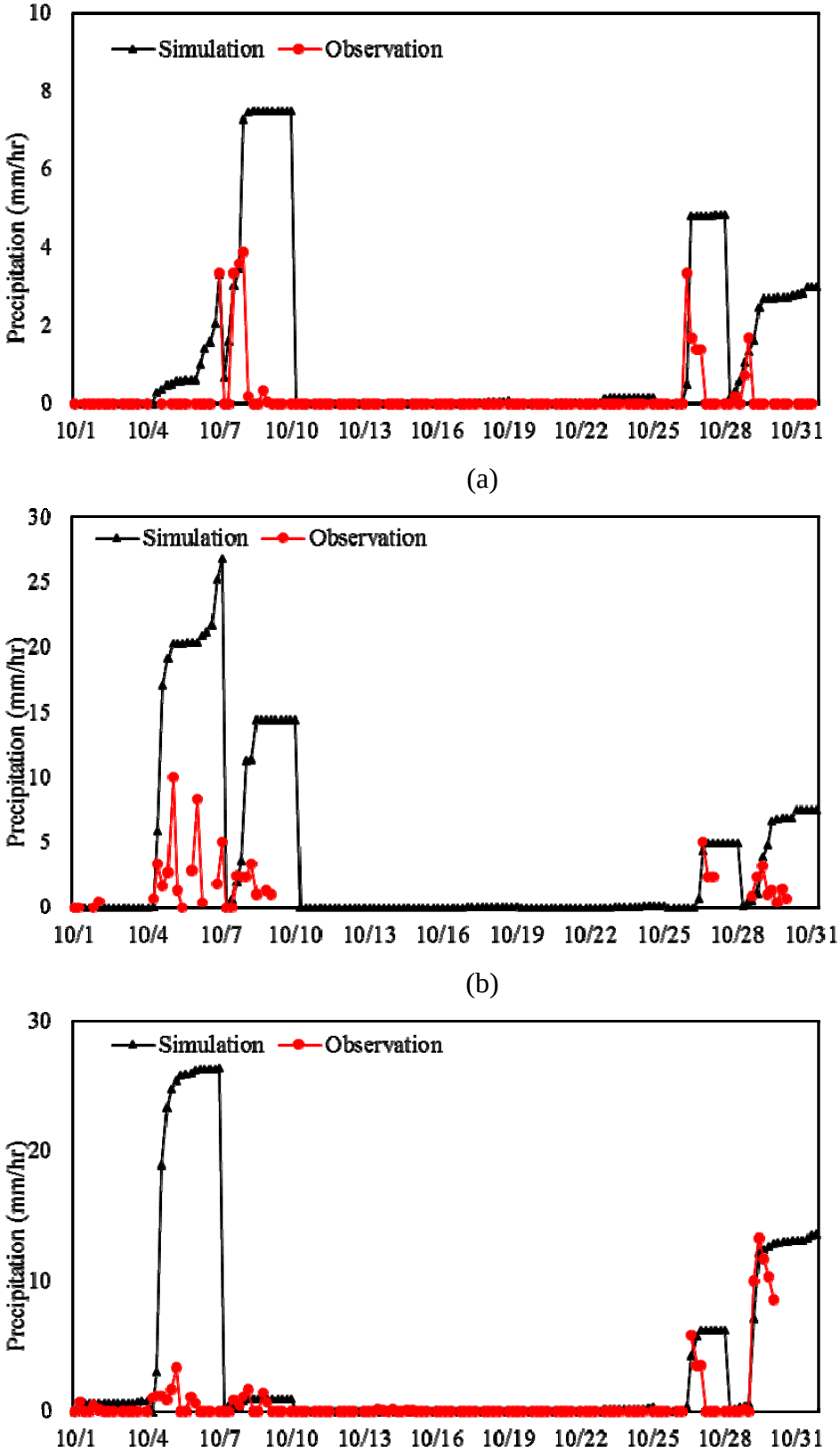


(b)



(c)

Figure S11.


Simulation
Observation
Precipitation (mm/hr)
10
8
6
4
2
0
10/1
10/4
10/7
10/10
10/13
10/16
10/19
10/22
10/25
10/28
10/31
(a)
30
25
20
15
10
5
0
(b)
(c)