

SUPPLEMENTARY MATERIAL

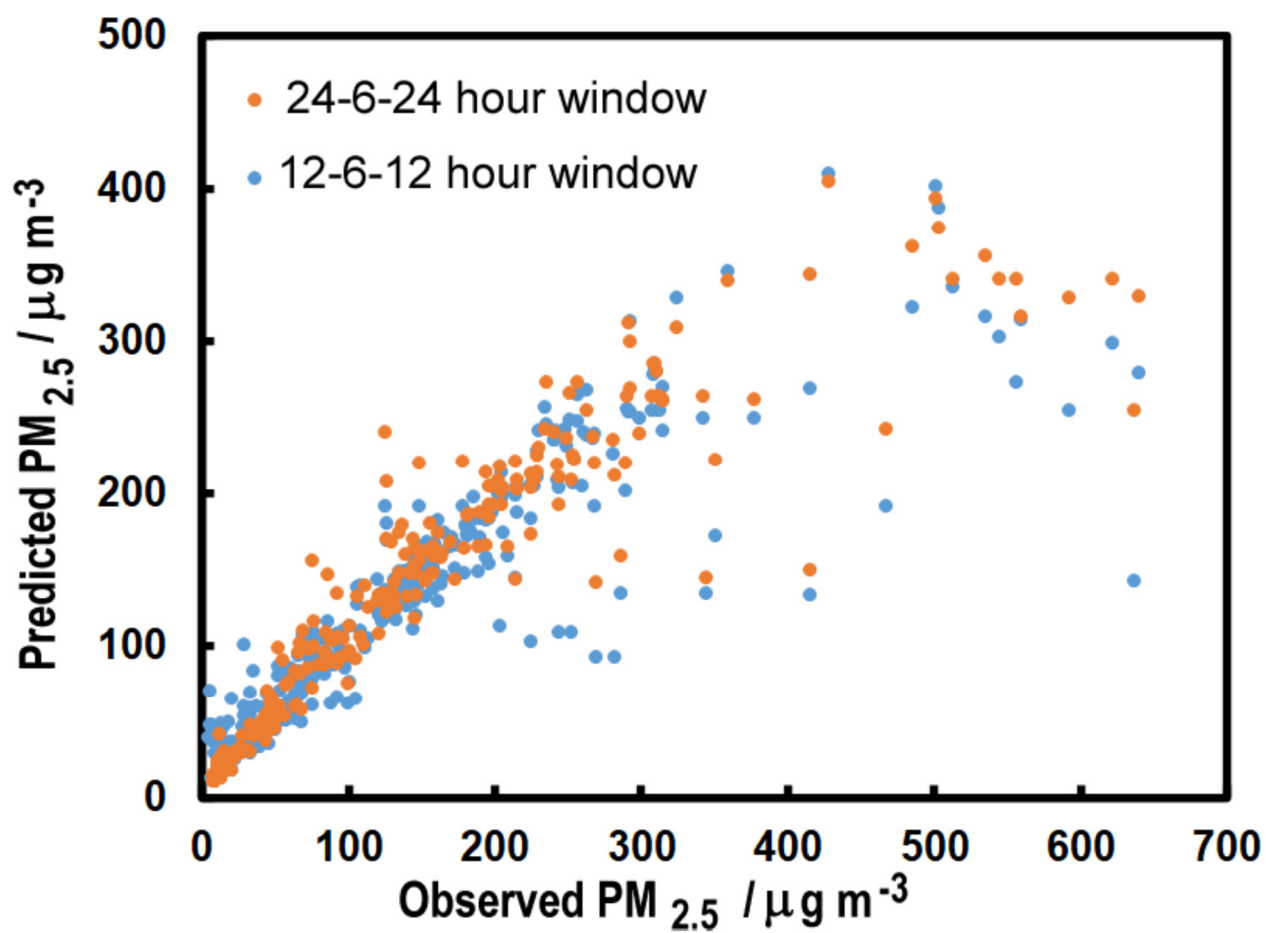


Figure S1 Comparison of observed and predicted PM_{2.5} concentrations using the random forest model trained using a window that covered 12 hours before and after the firework period (00.00/05.00) and a window covering a 24 hours before and after.

Table S1 Statistical results of Mann-Whitney test for PM₁₀, PM_{2.5}, NO₂ and SO₂ between New Year's Eve (before) [12:00/23:00] and fireworks period [00:00/05:00] in Beijing urban and suburban areas from 2014/2021.

	2014		2015		2016		2017		2018		2019		2020		2021	
PM10	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban
<i>N</i>	12/6	12/6	12/6	11/ 6	12/6	12/6	10/6	10/6	12/6	12/6	10/4	10/4	11/6	12/6	11/6	10/6
<i>Mb</i>	112.6	98.9	84.9	100.9	88.3	137.5	184.5	194.4	105.0	100.2	118.7	129.7	80.3	88.0	196.5	217.7
<i>Mf</i>	342.9	290.2	336.8	467.0	617.5	630.0	690.9	602.6	291.8	381.8	229.5	332.8	180.4	220.9	345.9	355.3
<i>U_A</i>	72	71	70	72	72	72	60	60	65	72	40	40	69	70	72	72
<i>p</i>	0.0009	0.0012	0.0017	0.0009	0.0009	0.0009	0.0014	0.0014	0.0067	0.0009	<0.05	<0.05	0.0024	0.0017	0.0009	0.0009
PM2.5	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban
<i>N</i>	12/6	12/6	12/6	11/ 6	12/6	12/6	10/6	10/6	12/6	12/6	10/4	10/4	11/6	12/6	11/6	10/6
<i>Mb</i>	74.6	71.9	63.6	77.2	44.9	83.2	129.6	140.9	88.3	85.7	54.2	58.7	70.8	72.0	203.9	179.0
<i>Mf</i>	266.9	237.2	277.4	392.0	498.0	528.5	538.9	491.0	246.7	319.7	152.4	223.5	150.8	174.2	274.8	274.6
<i>U_A</i>	67	69	68	66	72	72	60	60	66	72	40	40	64	70	66	57
<i>p</i>	0.0042	0.0024	0.0032	0.0012	0.0009	0.0009	0.0014	0.0014	0.0058	0.0009	<0.05	<0.05	0.0021	0.0017	0.0011	0.0041
NO2	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban
<i>N</i>			12/6	12/6	12/6	12/6	10/6	10/6	12/6	12/6	10/4	10/4	12/6	12/6	12/6	12/6
<i>Mb</i>			30.5	23.3	25.4	34.6	38.0	37.7	25.7	24.4	28.1	23.2	18.4	22.5	55.8	30.4
<i>Mf</i>			46.1	45.5	71.0	74.4	76.1	63.8	52.8	48.3	37.9	39.9	31.5	26.5	47.3	29.2
<i>U_A</i>			60	59	72	69	60	58	68	71	31.5	38	68	46	7*	32
<i>p</i>			0.03	0.03	0.0009	0.0024	0.0014	0.0029	0.0032	0.0012	>0.05	<0.05	0.0032	0.37	0.0076	0.74
SO2	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban	Urban	Suburban
<i>N</i>			12/6	12/6	12/6	12/6	10/6	10/6	12/6	12/6	10/4	10/4	12/6	12/6	12/6	12/6
<i>Mb</i>			23.8	29.2	21.1	29.1	35.4	38.8	17.4	17.5	7.2	8.2	5.6	9.3	11.3	10.6
<i>Mf</i>			78.4	98.1	154.1	144.9	122.1	109.6	41.8	54.8	10.1	14.2	7.4	7.4	8.6	4.8

U_A	65	69	72	72	60	59	64	71	40	40	58	17	5.5*	6*
p	0.0076	0.0024	0.0009	0.0009	0.0014	0.002	0.0099	0.0012	<0.05	<0.05	0.044	0.08	0.005	0.006

N is the number of sampler; Mb is the mean value for New Year’s Eve (before) [12:00/23:00]; Mf is the mean value for fireworks period [00:00/05:00]; *represents that the U_A value is smaller than the indicated lower limit, which means that the mean value during the before period[12:00/23:00] is significantly greater than that during the fireworks period.

Table S2 Mean random forest model performance statistics for five sets of 50 models grown for the analysis.

Area		Training set				Testing set			
		r2	MB	NMB	NRMSE	r2	MB	NMB	NRMSE
Beijing urban	PM10	0.80±0.01	-0.05±0.26	0.00±0.00	0.34±0.01	0.78±0.02	1.60±2.86	0.01±0.02	0.34±0.02
	PM2.5	0.83±0.01	0.06±0.22	0.00±0.00	0.35±0.01	0.83±0.02	-2.31±2.37	-0.01±0.02	0.34±0.02
	NO2	0.89±0.00	-0.15±0.04	0.00±0.00	0.19±0.00	0.88±0.01	-0.14±0.29	0.00±0.01	0.18±0.01
	SO2	0.88±0.00	-0.01±0.05	0.00±0.00	0.40±0.01	0.86±0.01	-0.05±0.52	0.01±0.02	0.42±0.02
Beijing suburban	PM10	0.81±0.01	-0.66±0.21	0.00±0.00	0.28±0.01	0.81±0.02	-1.48±2.22	-0.01±0.01	0.27±0.01
	PM2.5	0.86±0.00	-1.31±0.19	-0.01±0.00	0.27±0.00	0.86±0.01	-1.87±1.55	-0.01±0.01	0.27±0.01
	NO2	0.87±0.00	-0.22±0.03	-0.01±0.00	0.19±0.00	0.86±0.02	-0.27±0.33	-0.01±0.01	0.19±0.01
	SO2	0.89±0.00	-0.24±0.04	-0.01±0.00	0.34±0.00	0.89±0.01	-0.17±0.41	0.00±0.02	0.34±0.02
Chongqing	PM10	0.89±0.01	-0.37±0.08	0.00±0.00	0.13±0.00	0.89±0.01	-0.46±0.67	0.00±0.01	0.12±0.01
	PM2.5	0.87±0.00	-0.33±0.05	0.00±0.00	0.14±0.00	0.87±0.02	0.10±0.63	0.00±0.01	0.14±0.01

	NO2	0.76±0.01	-0.05±0.02	0.00±0.00	0.14±0.00	0.74±0.02	-0.22±0.19	-0.01±0.01	0.14±0.01
	SO2	0.91±0.00	-0.04±0.01	0.00±0.00	0.14±0.00	0.90±0.01	-0.10±0.12	-0.01±0.01	0.13±0.01
Tianjin	PM10	0.76±0.01	-0.75±0.26	-0.01±0.00	0.30±0.00	0.75±0.02	-1.23±2.31	0.00±0.02	0.29±0.01
	PM2.5	0.72±0.01	-0.41±0.18	0.00±0.00	0.32±0.00	0.73±0.02	0.88±1.51	0.01±0.02	0.30±0.02
	NO2	0.83±0.00	-0.07±0.03	0.00±0.00	0.18±0.00	0.82±0.01	-0.27±0.32	-0.01±0.01	0.17±0.01
	SO2	0.80±0.00	0.01±0.06	0.00±0.00	0.38±0.01	0.81±0.03	-0.34±0.66	0.00±0.02	0.35±0.03
Guangzhou	PM10	0.84±0.01	-0.39±0.13	-0.01±0.00	0.31±0.00	0.82±0.03	0.49±1.46	0.01±0.02	0.29±0.02
	PM2.5	0.83±0.01	-0.42±0.11	-0.01±0.00	0.38±0.01	0.83±0.03	-0.55±0.98	0.00±0.02	0.35±0.02
	NO2	0.73±0.01	0.11±0.05	0.00±0.00	0.35±0.00	0.71±0.03	0.21±0.58	0.01±0.02	0.34±0.02
	SO2	0.75±0.01	-0.01±0.01	0.00±0.00	0.33±0.01	0.77±0.02	-0.16±0.19	-0.01±0.02	0.30±0.02
Shenzhen	PM10	0.91±0.00	0.06±0.04	0.00±0.00	0.14±0.00	0.91±0.01	0.02±0.35	0.00±0.01	0.14±0.01
	PM2.5	0.85±0.00	0.00±0.03	0.00±0.00	0.19±0.00	0.87±0.02	-0.02±0.33	0.00±0.01	0.17±0.01
	NO2	0.75±0.01	0.03±0.02	0.00±0.00	0.29±0.00	0.75±0.02	-0.03±0.23	0.00±0.01	0.28±0.01
	SO2	0.75±0.01	0.01±0.01	0.00±0.00	0.21±0.00	0.76±0.03	0.04±0.08	0.01±0.01	0.21±0.02

Table S3 Statistical results of Mann-Whitney test for PM₁₀, PM_{2.5}, NO₂ and SO₂ between New Year's Eve (before) [12:00/23:00] and fireworks period [00:00/05:00] in Tianjin from 2015 to 2021 .

	2015	2016	2017	2018	2019	2020	2021
PM10							
<i>N</i>	12/6	12/6	12/6	11/6	12/6	12/6	12/6
<i>Mb</i>	84.6	187.7	112.8	94.2	239.3	38.7	145.5
<i>Mf</i>	247.2	472.9	288.0	191.7	392.2	19.1	168.5
<i>U_A</i>	68	71	65	66	72	27	60
<i>p</i>	0.0032	0.0012	0.0076	0.0011	0.0009	0.42	0.0278
PM2.5							
<i>N</i>	12/6	12/6	12/6	11/6	12/6	12/6	12/6
<i>Mb</i>	49.9	105.0	77.1	84.1	130.8	49.7	107.4
<i>Mf</i>	143.4	337.0	236.3	148.6	263.9	24.6	128.8
<i>U_A</i>	71	72	69	65	72	24	64
<i>p</i>	0.0012	0.0009	0.0024	0.0015	0.0009	0.28	0.0099

<i>N</i>	12/6	12/6	12/6	11/6	12/6	12/6	12/6
<i>Mb</i>	95.2	72.3	121.0	83.0	54.2	52.6	35.6
<i>Mf</i>	177.3	195.6	135.2	186.5	64.3	32.3	80.9
<i>U_A</i>	70	72	46	66	64	0*	66
<i>p</i>	0.0017	0.0009	0.37	0.0011	0.0021	0.0011	0.0011
NO2							
<i>N</i>	12/6	12/6	12/6	11/6	12/6	12/6	12/6
<i>Mb</i>	31.6	36.8	35.8	31.3	29.9	20.3	25.6
<i>Mf</i>	27.3	37.6	23.4	35.0	30.8	14.3	30.0
<i>U_A</i>	23	39	0*	46	40	0*	48
<i>p</i>	0.24	0.81	0.0009	0.21	0.52	0.0011	0.14
SO2							
<i>N</i>	12/6	12/6	12/6	11/6	12/6	12/6	12/6
<i>Mb</i>	23.0	20.0	20.4	10.1	14.4	5.4	8.2
<i>Mf</i>	28.9	38.4	18.9	29.6	12.7	5.2	9.8
<i>U_A</i>	39	67	19	66	17	9.5*	62.5
<i>p</i>	0.81	0.0042	0.12	0.0011	0.12	0.02	0.0036

Table S5 Statistical results of Mann-Whitney test for PM₁₀, PM_{2.5}, NO₂ and SO₂ between New Year's Eve (before) [12:00/23:00] and fireworks period [00:00/05:00] in Guangzhou from 2015 to 2021.

	2015	2016	2017	2018	2019	2020	2021
PM10							
<i>N</i>	12/6	12/6	12/6	11/6	12/6	12/6	12/6
<i>Mb</i>	78.1	42.8	62.6	69.2	47.0	32.2	14.9
<i>Mf</i>	120.6	127.1	165.9	118.8	47.4	58.1	64.8
<i>U_A</i>	67	71	71	64	43	68	72
<i>p</i>	0.0042	0.0012	0.0012	0.0021	0.54	0.0032	0.0009
PM2.5							
<i>N</i>	12/6	12/6	12/6	11/6	12/6	12/6	12/6
<i>Mb</i>	50.1	23.2	41.1	44.1	33.2	20.3	10.2
<i>Mf</i>	77.9	132.9	118.4	204.0	36.5	43.3	53.6
<i>U_A</i>	67	72	72	66	51	70	72
<i>p</i>	0.0042	0.0009	0.0009	0.0011	0.17	0.0017	0.0009
NO2							
<i>N</i>	12/6	12/6	12/6	11/6	12/6	12/6	12/6
<i>Mb</i>	38.3	33.2	45.9	39.2	20.4	21.6	13.2
<i>Mf</i>	34.0	60.5	66.1	72.9	16.0	20.3	17.6
<i>U_A</i>	35	57	51	52	30.5	35.5	63
<i>p</i>	0.96	0.055	0.17	0.061	0.638	1	0.0131
SO2							
<i>N</i>	12/6	12/6	12/6	11/6	12/6	12/6	12/6
<i>Mb</i>	6.9	8.6	9.2	9.3	4.2	5.1	5.7
<i>Mf</i>	18.3	63.2	32.9	42.9	5.3	11.1	15.8

N	12/6	12/6	12/6	11/6	12/6	12/6	12/6
Mb	8.3	10.7	8.5	8.8	5.8	4.9	5.2
Mf	14.5	26.5	12.8	11.5	6.3	5.3	7.6
U_A	59.5	72	60	52.5	37	48.5	72
p	0.0316	0.0009	0.0278	0.0561	0.9601	0.2627	0.0009

Table S7 Statistical results of Mann-Whitney test for PM₁₀ and PM_{2.5} comparing observations and simulation (00:00/05:00); showing for the earlier periods when the fireworks are allowed in there is a more significant difference between observation and simulation during fireworks period central Beijing, Chongqing and Tianjin. Bans have been less restrictive in Beijing beyond the 5th Ring Road, while they long been effective in Guangzhou and in place for some time.

M-W test	00:00-05:00	PM10				PM2.5		
	Period	Statistic U_A	z	P value		Statistic U_A	z	P value
Beijing central	2014-2017	142	3	0.0003		135	3.14	0.0017
	2018-2021	228.5	1.22	0.2225		271	0.34	0.7339
Beijing outer	2014-2017	114	3.58	0.0003		110	3.66	0.0003
	2018-2021	90	4.07	<.0001		136	3.21	0.0018
Chongqing	2015-2018	53	4.84	<.0001		36	5.19	<.0001
	2019-2021	199	-1.15	0.2501		195	-1.03	0.303
Tianjin	2015-2018	181	2.2	0.0278		153	2.77	0.0056
	2019-2021	175	-0.4	0.6892		172	-0.3	0.7642
Guangzhou	2015-2021	972.5	-0.81	0.4179		880.5	0.01	0.992
Shenzhen	2015-2021	779	0.92	0.3576		800	0.73	0.4654