Supplement of

The Aggravated Air Pollution and Health Burden due to Traffic Congestion in Urban China

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Text S1. All statistics equations related to the model validation are shown below:

$$\mathbf{MB} = \frac{1}{N}\sum_{i=1}^{N}(C_m - C_o)$$

$$\mathbf{GE} = \frac{1}{N}\sum_{i=1}^{N}|C_m - C_o|$$

$$\mathbf{RMSE} = \sqrt{\frac{\sum_{i=1}^{N}(C_m - C_o)^2}{N}}$$

$$\mathbf{MFB} = \frac{1}{N}\sum_{i=1}^{N}\frac{(C_m - C_o)}{\left(\frac{C_o + C_m}{2}\right)}$$

$$\mathbf{MNB} = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{C_m - C_o}{C_o}\right)$$

$$\mathbf{MNE} = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{C_m - C_o}{C_o}\right|$$

In these equations $\boldsymbol{C_m}$ represents the model results, $\boldsymbol{C_o}$ represents the observations, and $\boldsymbol{N}$ is the number of data points, $\boldsymbol{i}$ represents a data point.

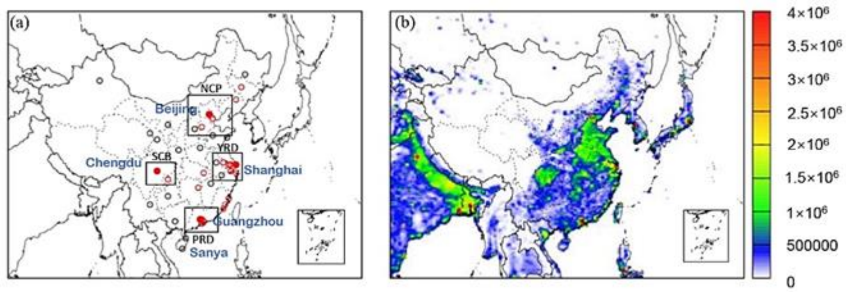

Figure S1. (a) is the CMAQ study domain and the key cities in China, and (b) is population data used in this study. For panel (a), red circle: cities in the TomTom data base, red dot: megacities (Beijing, Shanghai, Guangzhou, and Chengdu), black circle: other key cities in China such as the provincial capital.

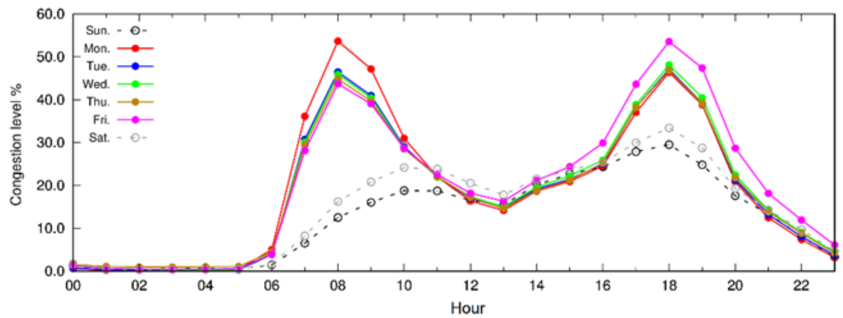

Figure S2. The 22-city average weekly congestion level (in %) from TomTom in 2020.

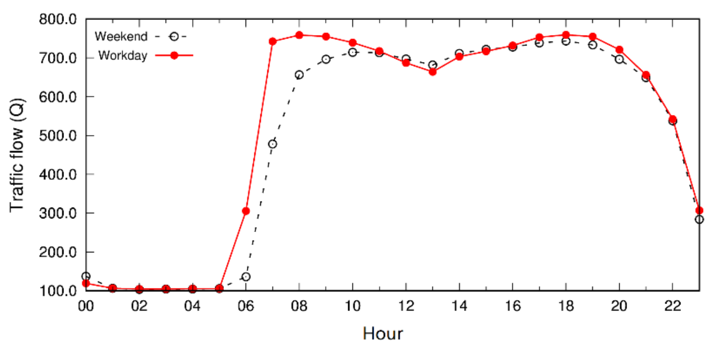

Figure S3. The 22-city average hourly diurnal traffic flow calculated from TomTom congestion data in 2020.

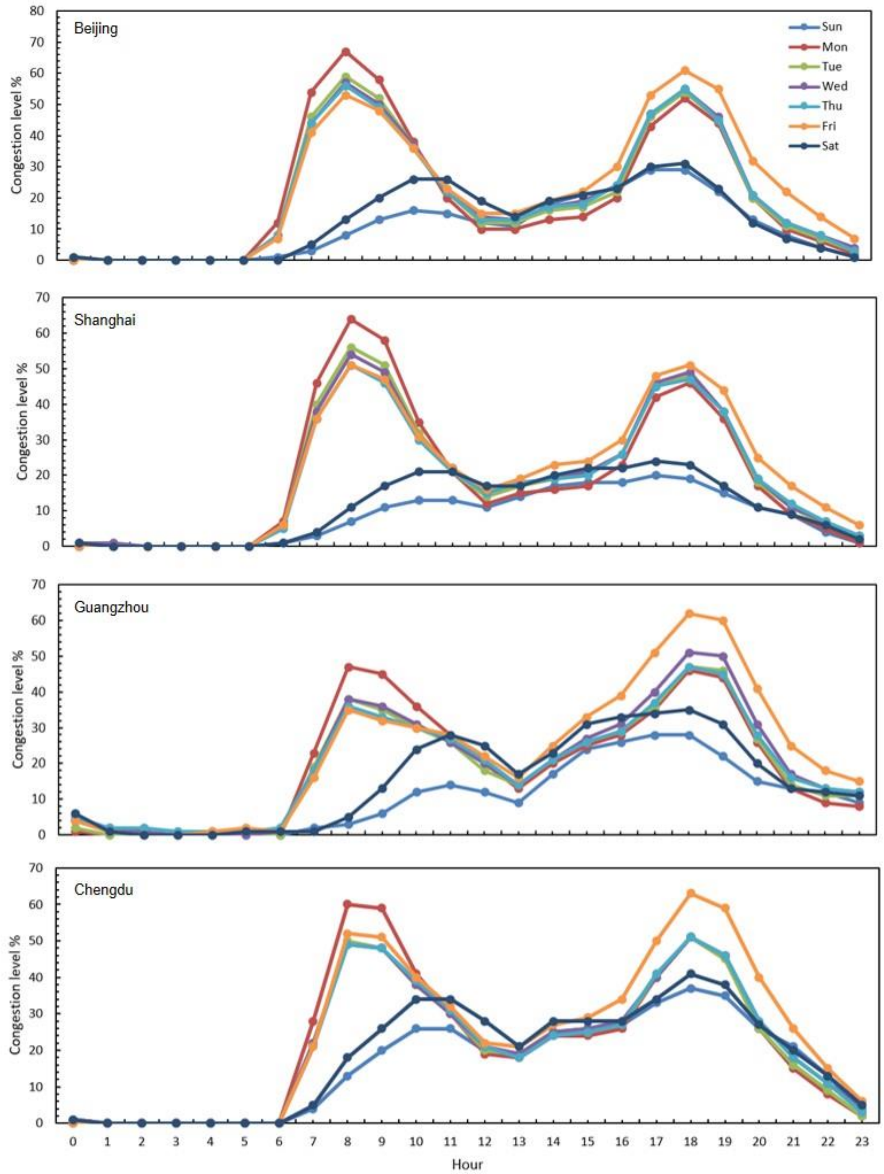

Figure S4. The weekly congestion level (in %) from TomTom in 2020 in Beijing, Shanghai, Guangzhou, and Chengdu, respectively.

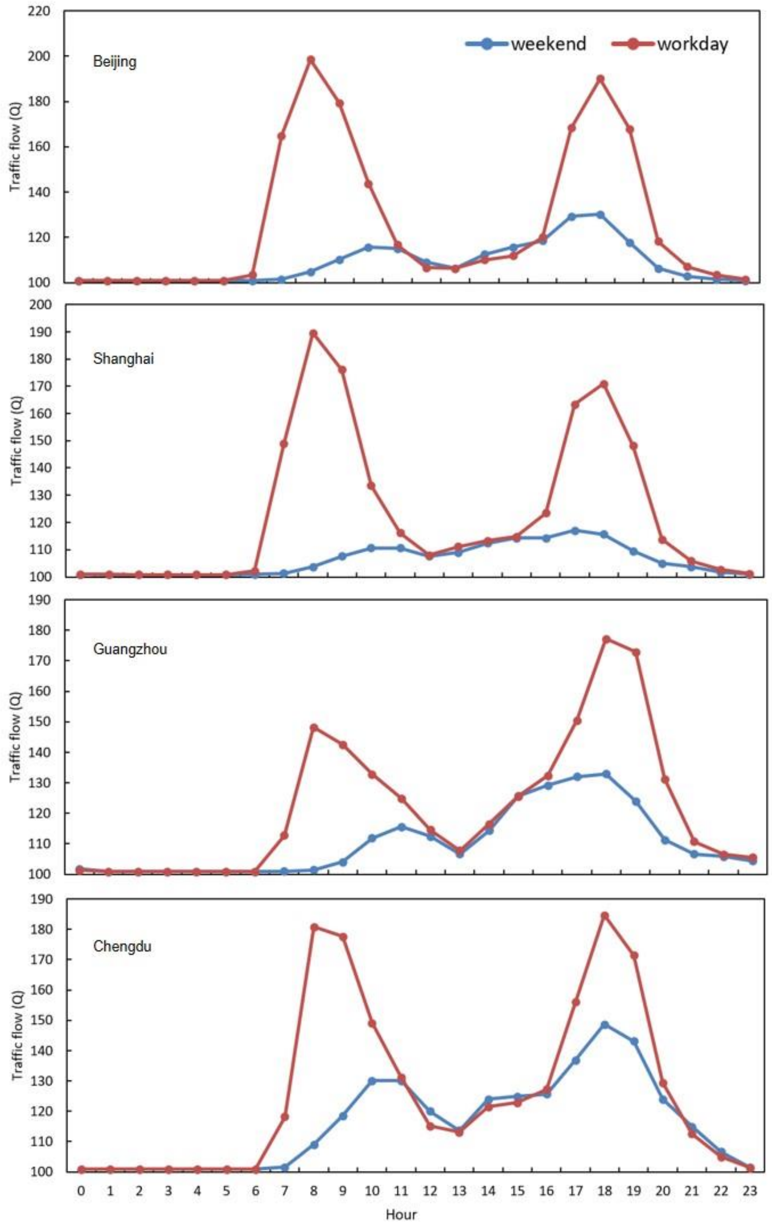

Figure S5. The hourly diurnal traffic flow calculated from TomTom congestion data in 2020 in Beijing, Shanghai, Guangzhou, and Chengdu, respectively.

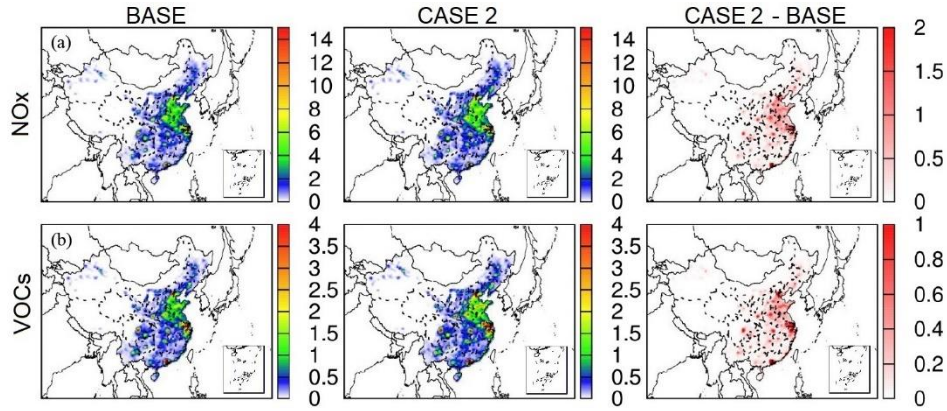

Figure S6. The annual average anthropogenic NOx and VOCs emissions of BASE and CASE 2, and their differences between these two cases (CASE 2-BASE) in 2020. Units are moles s^{-1}.

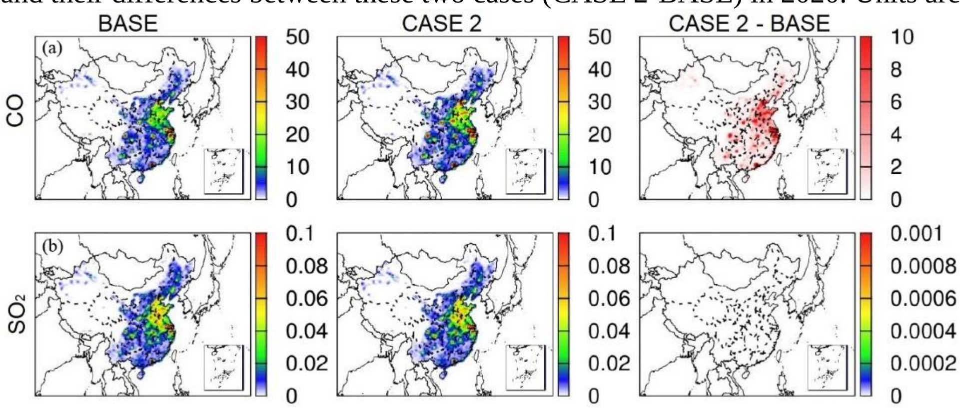

Figure S7. The annual average anthropogenic CO and SO_2 emissions of BASE and CASE 2, and their differences between these two cases (CASE 2-BASE) in 2020. Units are moles s^{-1}.

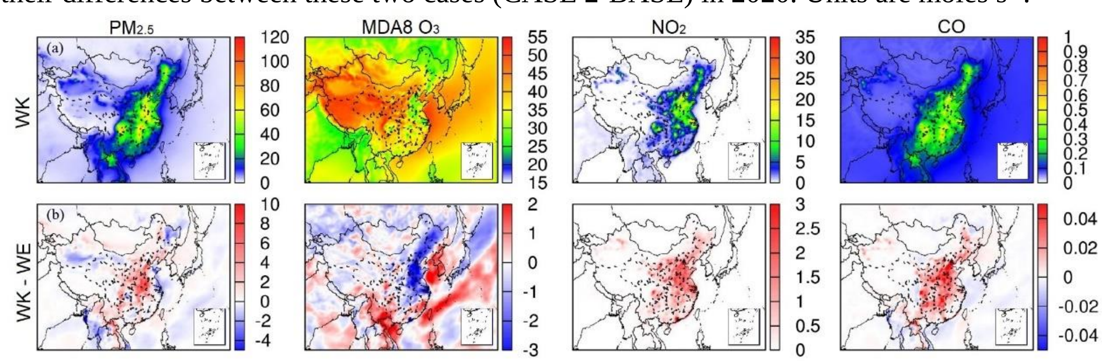

Figure S8. (a) is the concentration of $PM_{2.5}$, MDA8 O_3, NO_2, and CO on workday (WK), and (b) is the differences of these pollutants between WK and weekend (WE) of CASE 2. Unit for $PM_{2.5}$ is µg m^{-3}, ppb for MDA8 O_3 and NO_2, and ppm for CO.

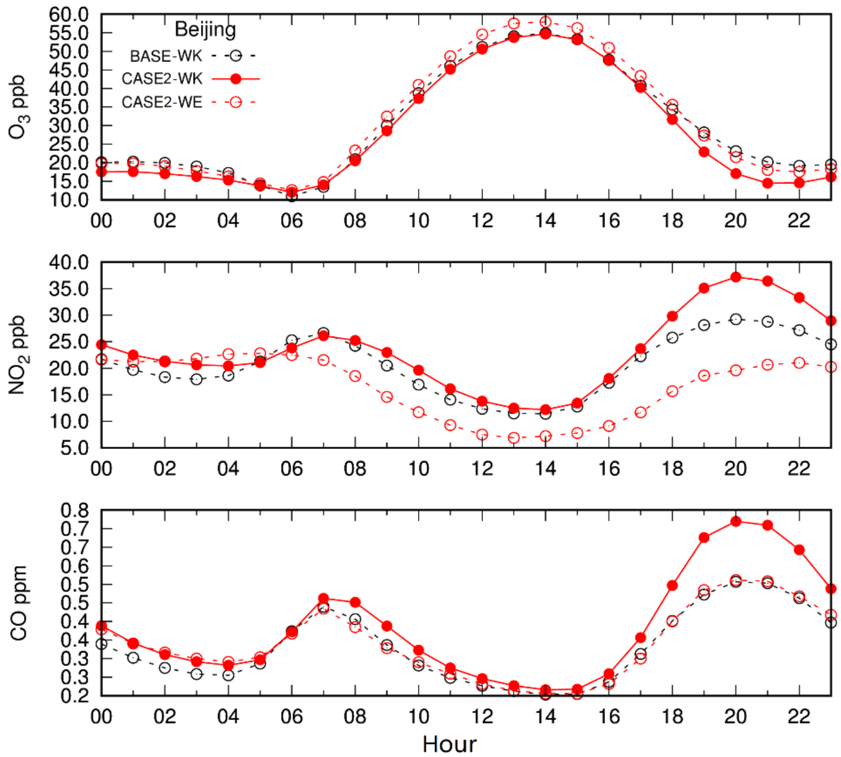

Figure S9. The diurnal O_3, NO_2, and CO concentrations of BASE and CASE 2 in Beijing. WK: workday, and WE: weekend.

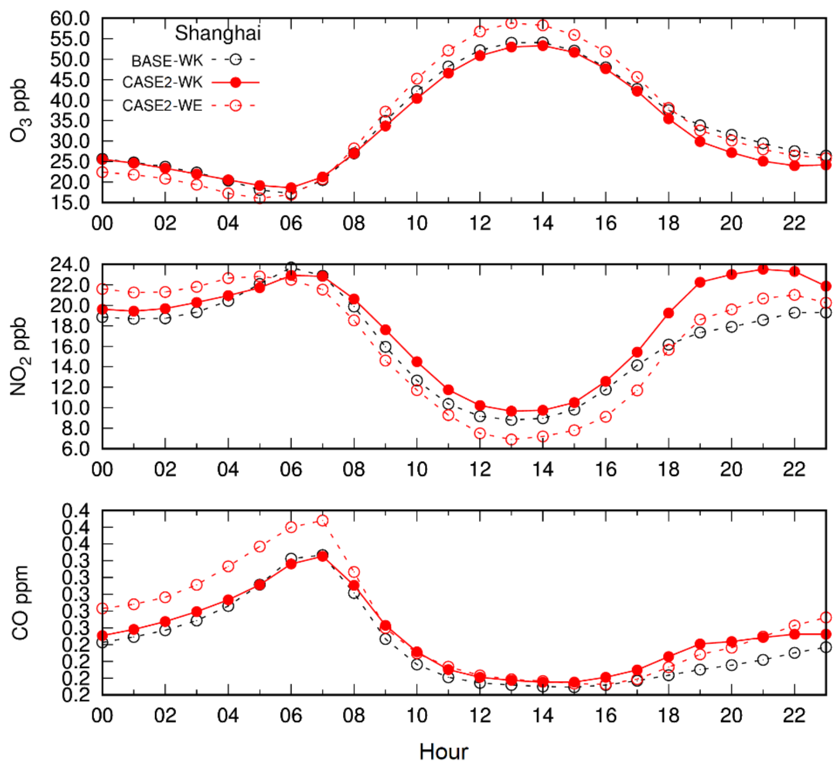

Figure S10. The diurnal O_3, NO_2, and CO concentrations of BASE and CASE 2 in Shanghai. WK: workday, and WE: weekend.

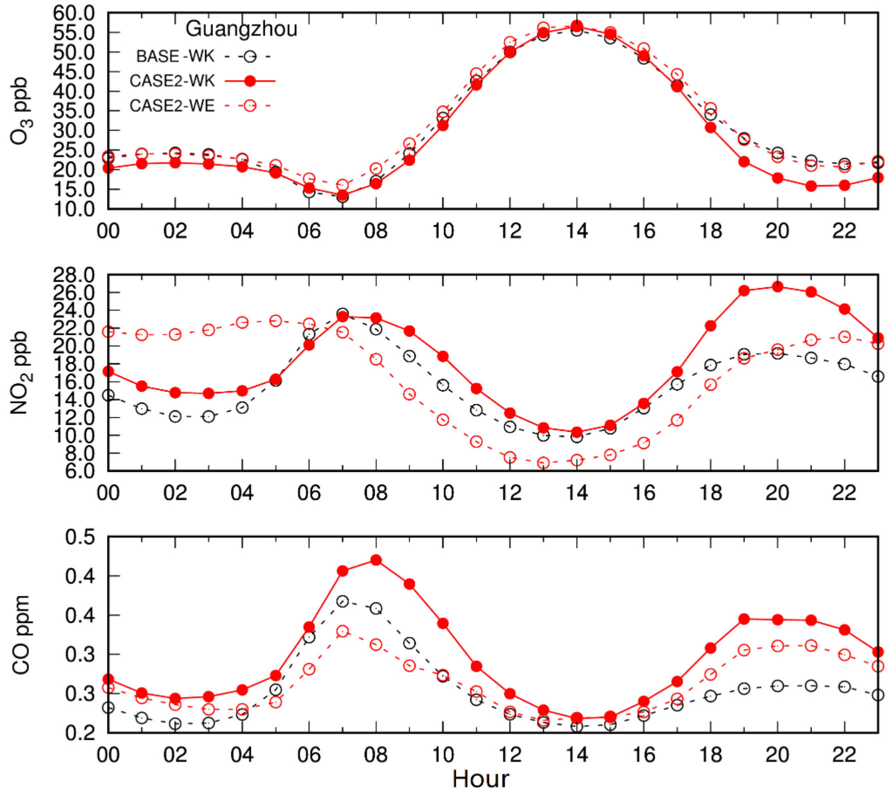

Figure S11. The diurnal O_3, NO_2, and CO concentrations of BASE and CASE 2 in Guangzhou. WK: workday, and WE: weekend.

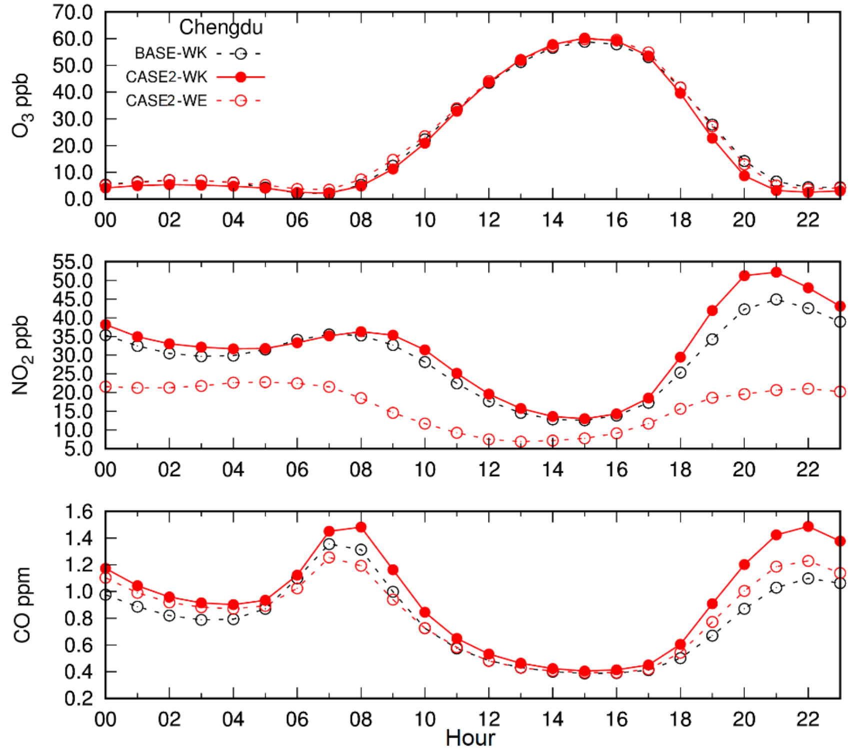

Figure S12. The diurnal O_3, NO_2, and CO concentrations of BASE and CASE 2 in Chengdu. WK: workday, and WE: weekend.

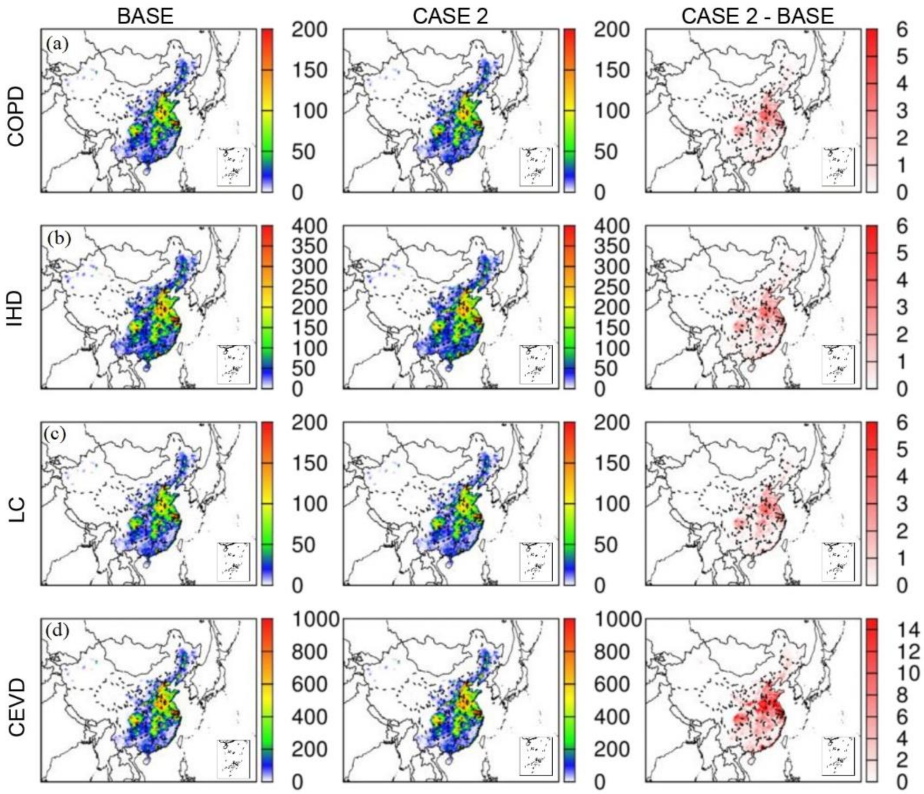

Figure S13. The $PM_{2.5}$-related premature mortality of (a) COPD, (b) IHD, (c) LC, and (d) CEVD for BASE and CASE 2 and their differences.

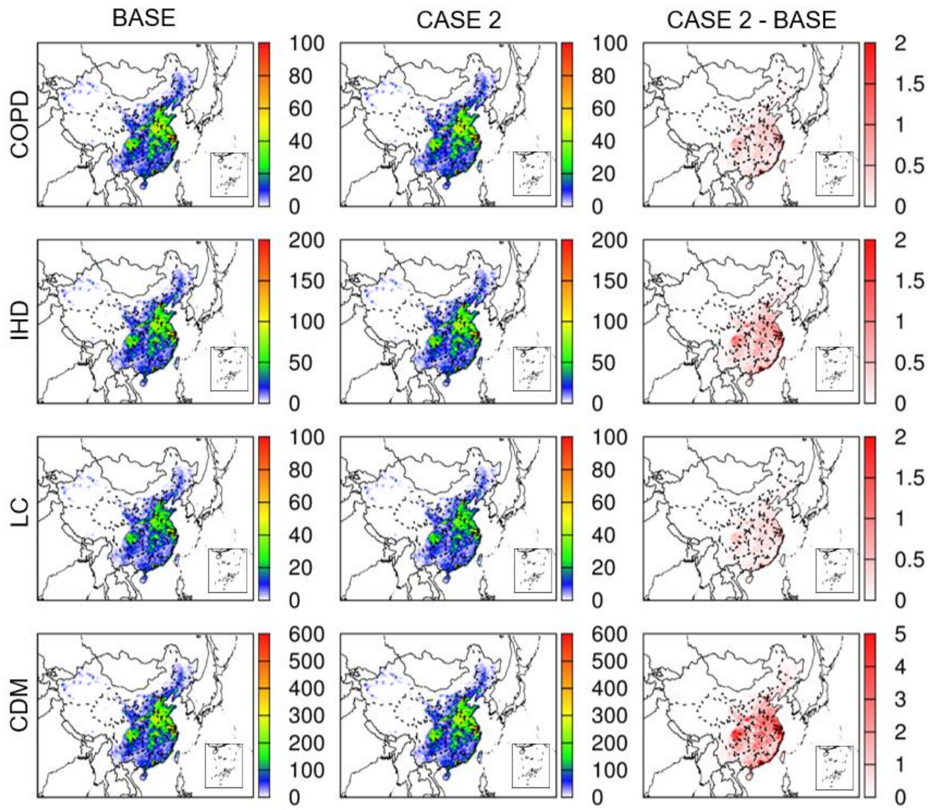

Figure S14. The O_3-related premature mortality of (a) COPD, (b) IHD, (c) LC, and (d) CDM for BASE and CASE 2 and their differences.

Table S1. The emission correction factors in this study.

Pollutant	Speed range (km h^{-1})			
	< 20	20-30	30-40	> 40
CO	1.69	1.26	0.79	0.39
NMVOC*	1.68	1.25	0.78	0.32
NO_x	1.38	1.13	0.9	0.86
PM	1.68	1.25	0.78	0.32

*NMVOC: non-methane VOCs.

Table S2. Meteorology performance in all the months in 2020 (OBS is mean observation; PRE is mean prediction; MB is mean bias; GE is gross error; RMSE is root mean square error). The benchmarks are suggested by Emery, et al. [1]. The values that do not meet the criteria are denoted in the bold. The related equations are shown in the Text S1.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Bench-mark
T2 (K)	OBS	273.9	277.1	282.5	286.6	293.0	296.0	297.5	297.4	293.1	286.7	283.7	273.4	
	PRE	274.7	277.5	282.4	286.0	292.7	295.5	297.3	297.0	292.5	286.3	283.5	274.0	
	MB	**0.9**	0.4	0.0	**-0.6**	-0.3	**-0.5**	-0.2	-0.4	**-0.6**	-0.4	-0.2	**0.6**	≤ ±0.5
	GE	**3.5**	**2.6**	**2.2**	**2.8**	**2.7**	**2.5**	**2.2**	**2.5**	**2.7**	**2.5**	**2.4**	**2.8**	≤ 2.0
	RMSE	4.6	3.5	3.2	3.8	3.5	3.3	3.1	3.3	3.6	5.5	3.2	3.7	
WS (ms^{-1})	OBS	2.9	3.1	3.3	3.4	3.3	3.2	3.0	3.0	2.9	3.2	3.2	3.2	
	PRE	3.9	4.0	4.3	4.2	4.1	4.0	3.7	3.6	3.4	3.9	4.1	4.1	
	MB	**1.0**	**0.8**	**1.0**	**0.8**	**0.7**	**0.8**	**0.7**	0.5	0.5	**0.8**	**0.9**	**1.0**	≤ ±0.5
	GE	2.0	1.9	2.0	1.9	1.9	1.8	1.7	1.7	1.6	1.8	1.9	2.0	≤ 2.0
	RMSE	**2.6**	**2.5**	**2.6**	**2.5**	**2.4**	**2.4**	**2.3**	2.0	1.9	**2.4**	**2.5**	**2.6**	≤ 2.0
WD (°)	OBS	172.4	174.3	177.4	170.7	180.9	177.3	172.3	170.8	166.8	174.9	177.8	188.8	
	PRE	152.2	165.8	172.7	163.3	185.2	181.6	174.6	171.6	156.9	168.5	158.1	158.4	
	MB	-6.7	-0.6	2.2	-0.1	7.2	6.4	4.4	4.3	-2.4	-6.4	-7.2	-9.9	≤ ±10
	GE	**47.2**	**47.4**	**44.0**	**47.8**	**47.4**	**46.2**	**44.5**	**44.2**	**47.6**	**41.1**	**39.7**	**44.5**	≤ ±30
	RMSE	64.0	64.0	60.9	64.6	64.0	63.0	61.1	60.5	64.0	47.8	37.0	61.2	
RH (%)	OBS	78.9	76.6	73.6	67.0	66.5	68.5	70.9	72.1	73.2	73.3	69.2	75.6	
	PRE	81.1	80.6	76.6	69.9	67.2	70.0	73.4	75.5	75.8	77.2	74.3	79.0	
	MB	2.2	3.9	2.9	2.9	0.8	1.5	2.5	3.4	2.6	3.9	5.2	3.4	
	GE	19.8	13.1	13.8	14.8	16.3	14.5	15.1	14.5	13.9	13.9	13.7	13.4	
	RMSE	23.0	16.9	17.9	19.1	20.3	18.6	19.6	18.9	18.3	18.0	17.4	17.2	

Table S3. Model performance in BASE case on O_3-1 h, $PM_{2.5}$, PM_{10}, CO, NO_2, and SO_2 in January to December 2020 (MFE is mean fractional error; MNB is mean normalized bias; MNE is mean normalized error). The performance criteria for $PM_{2.5}$ are suggested by EPA (2007)[2] , and the performance criteria for O_3 are suggested by EPA (2005)[3]. The values that do not meet the criteria are denoted in bold. The related equations are shown in the Text S1.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Criteria
O_3-1h (ppb)	OBS	46.88	47.61	54.44	56.70	59.04	62.83	60.53	59.04	60.07	54.46	53.94	49.16	
	PRE	52.65	55.82	54.12	59.72	60.45	63.54	61.93	62.47	61.25	53.28	53.40	52.32	
	MFB	0.11	0.15	0.00	0.05	0.03	0.02	0.02	0.05	0.02	-0.02	-0.01	0.06	
	MFE	0.17	0.19	0.20	0.16	0.16	0.18	0.18	0.19	0.17	0.15	0.16	0.15	
	MNB	0.14	**0.18**	0.03	0.08	0.05	0.04	0.05	0.09	0.05	0.00	0.02	0.08	≤ ±0.15
	MNE	0.19	0.22	0.21	0.17	0.17	0.19	0.19	0.20	0.18	0.15	0.17	0.16	≤ 0.3
$PM_{2.5}$ ($\mu g \cdot m^{-3}$)	OBS	74.91	47.72	39.24	41.35	33.05	29.95	29.15	26.37	29.66	39.21	46.68	63.43	
	PRE	81.50	67.74	57.95	34.24	26.10	26.71	27.90	32.31	40.04	39.00	49.89	73.61	
	MFB	0.03	0.22	0.17	-0.21	-0.26	-0.17	-0.11	0.08	0.14	-0.09	-0.01	0.05	≤ ±0.6
	MFE	0.58	0.60	0.65	0.54	0.52	0.53	0.51	0.49	0.51	0.55	0.54	0.54	≤ 0.75
	MNB	0.43	0.79	0.83	0.03	-0.05	0.10	0.15	0.40	0.54	0.25	0.33	0.38	
	MNE	0.82	1.08	1.17	0.57	0.52	0.62	0.61	0.71	0.83	0.71	0.73	0.73	
PM_{10} ($\mu g \cdot m^{-3}$)	OBS	89.12	63.34	70.02	74.66	64.36	54.49	44.85	42.16	49.39	67.31	74.27	87.60	
	PRE	84.09	69.55	57.46	37.64	31.04	29.70	28.82	32.55	41.05	42.32	53.65	76.34	
	MFB	-0.10	0.03	-0.22	-0.60	-0.62	-0.51	-0.44	-0.31	-0.25	-0.44	-0.33	-0.22	
	MFE	0.59	0.61	0.70	0.76	0.74	0.70	0.64	0.57	0.58	0.68	0.63	0.57	
	MNB	0.25	0.49	0.23	-0.31	-0.35	-0.23	-0.19	-0.09	0.03	-0.13	-0.05	0.03	
	MNE	0.73	0.90	0.85	0.60	0.57	0.59	0.56	0.54	0.63	0.63	0.62	0.58	
CO (ppm)	OBS	0.88	0.64	0.54	0.52	0.50	0.49	0.50	0.50	0.54	0.57	0.64	0.78	
	PRE	0.54	0.44	0.38	0.26	0.22	0.21	0.21	0.21	0.28	0.28	0.35	0.46	
	MFB	-0.53	-0.43	-0.42	-0.69	-0.78	-0.78	-0.82	-0.80	-0.68	-0.71	-0.62	-0.56	
	MFE	0.69	0.64	0.67	0.76	0.83	0.84	0.86	0.85	0.76	0.78	0.72	0.69	
	MNB	-0.28	-0.20	-0.14	-0.44	-0.50	-0.50	-0.52	-0.50	-0.42	-0.45	-0.38	-0.33	
	MNE	0.55	0.54	0.60	0.54	0.58	0.58	0.59	0.59	0.55	0.56	0.53	0.52	
NO_2 (ppb)	OBS	14.95	9.14	13.05	13.86	10.88	9.73	9.01	8.72	11.79	14.81	16.90	19.38	
	PRE	11.30	10.76	10.02	8.53	7.09	7.29	6.85	7.14	9.50	10.35	11.85	12.39	
	MFB	-0.37	-0.07	-0.42	-0.66	-0.62	-0.52	-0.50	-0.42	-0.41	-0.51	-0.50	-0.55	
	MFE	0.72	0.72	0.83	0.86	0.86	0.83	0.81	0.77	0.75	0.74	0.71	0.72	
	MNB	0.01	0.51	0.88	-0.30	-0.23	-0.09	-0.09	0.00	-0.05	-0.19	-0.21	-0.27	
	MNE	0.73	1.02	0.88	0.66	0.70	0.76	0.74	0.77	0.70	0.62	0.58	0.56	
SO_2 (ppb)	OBS	4.69	3.62	3.55	3.66	3.17	2.88	2.64	2.69	2.99	3.58	4.05	4.77	
	PRE	5.14	4.11	3.70	2.77	2.21	2.13	1.94	2.17	2.86	3.31	4.37	5.74	
	MFB	-0.15	-0.12	-0.24	-0.48	-0.61	-0.59	-0.57	-0.51	-0.36	-0.28	-0.15	-0.03	
	MFE	0.81	0.81	0.85	0.86	0.95	0.97	0.96	0.95	0.88	0.79	0.76	0.74	
	MNB	0.77	0.74	0.57	0.05	-0.04	0.05	0.04	0.15	0.33	0.30	0.50	0.73	
	MNE	1.38	1.33	1.25	0.90	0.91	1.00	0.97	1.03	1.10	0.99	1.09	1.24	

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