Supplement of

Effects of ozone-vegetation interactions on meteorology and air quality in China using a two-way coupled land-atmosphere model

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Table S1. Physics options used in model simulations

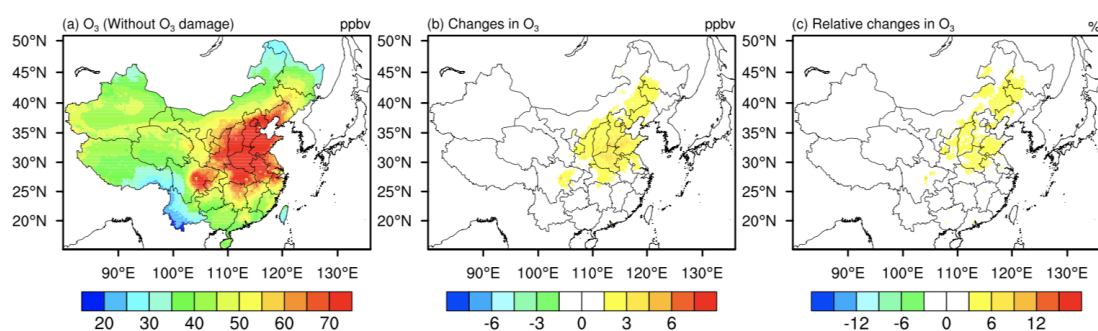| Physics	Scheme
Cloud microphysics	Morrison double-moment
Cumulus parameterization	Grell-3D
Longwave radiation	RRTMG
Shortwave radiation	Goddard
Land-surface physics	Noah-MP
Planetary boundary layer	Mellor-Yamada-Janjic

Figure S1. Spatial distribution of 2014–2017 JJA daytime mean **(a)** surface O_3 concentration, and **(b)** absolute changes and **(c)** relative changes in O_3.
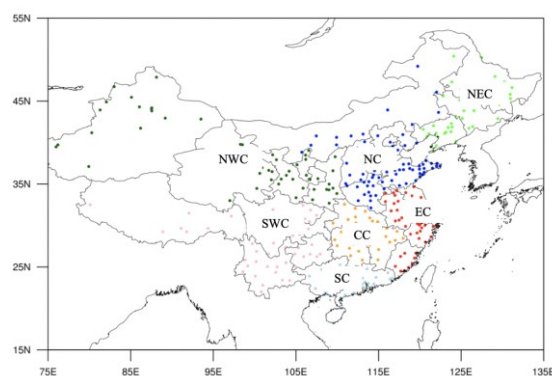

Figure S2. The location air quality monitoring sites (colored dots) and the seven major geographic regions of China. The region covered by light green dots is northeast China (NEC), blue dots cover north China (NC), and dark green dots cover northwest China (NWC). Red dots cover east China (EC), oranges cover central China (CC), pinks dots cover southwest China (SWC), and light blue dots cover south China (SC).

Table S2. Same as Table 3, but for the evaluation of the original model simulations.

	Year	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
T_{2m}	2014	25.41	2.61	24.86	2.29	0.86	0.87	−0.54
(°C)	2015	25.41	2.56	24.49	2.23	0.86	0.89	−0.91
	2016	26.35	2.82	25.25	2.65	0.84	0.83	−1.10
	2017	26.29	3.17	25.10	3.17	0.81	0.78	−1.18
RH_{2m}	2014	74.77	10.22	80.71	8.44	0.67	0.71	5.94
（%）	2015	73.34	10.75	82.16	8.16	0.65	0.74	8.82
	2016	74.14	10.81	83.46	9.20	0.67	0.73	9.32
	2017	73.24	11.65	81.56	9.18	0.67	0.69	8.32
WS_{10m}	2014	1.84	0.66	2.21	1.15	0.54	0.40	0.36
（m s^{-1}）	2015	2.00	0.74	2.45	1.34	0.55	0.44	0.46
	2016	1.99	0.70	2.48	1.34	0.54	0.44	0.48
	2017	2.02	0.72	2.50	1.41	0.53	0.46	0.49

Table S3. Same as Table 4, but for the evaluation of the original model simulations.

	Year	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
O_3	2014	29.79	9.95	50.13	17.9	0.48	0.57	20.75
(ppb)	2015	32.04	10.16	47.82	17.73	0.55	0.55	15.80
	2016	33.28	10.59	47.15	17.53	0.57	0.56	13.83
	2017	35.74	11.71	48.24	18.88	0.63	0.66	12.55
$PM_{2.5}$	2014	46.30	21.52	64.42	27.59	0.51	0.33	19.84
($\mu g\ m^{-3}$)	2015	38.52	17.30	58.33	25.67	0.55	0.43	19.47
	2016	31.86	13.96	57.98	26.06	0.47	0.40	25.82
	2017	28.82	12.23	57.17	26.00	0.40	0.30	28.46
PM_{10}	2014	80.79	31.62	72.99	29.11	0.47	0.22	−6.17
($\mu g\ m^{-3}$)	2015	72.03	29.74	66.75	27.14	0.50	0.28	−6.00
	2016	59.68	22.21	66.38	27.67	0.49	0.24	6.01
	2017	57.83	22.18	65.71	27.56	0.41	0.14	7.85
SO_2	2014	6.11	2.36	8.37	3.16	0.48	0.41	2.33
(ppb)	2015	4.78	1.89	8.32	3.19	0.45	0.44	3.56
	2016	4.17	1.57	7.97	3.13	0.41	0.35	3.80
	2017	3.83	1.33	8.56	3.49	0.36	0.41	4.76
NO_2	2014	17.20	4.51	17.56	4.69	0.41	0.26	0.41
(ppb)	2015	16.01	4.47	17.61	5.00	0.43	0.32	1.67
	2016	15.29	4.29	17.58	5.13	0.43	0.32	2.30
	2017	15.83	4.37	18.09	5.15	0.43	0.32	2.27
CO	2014	0.76	0.19	0.44	0.11	0.48	0.42	−0.31
(ppm)	2015	0.67	0.15	0.45	0.11	0.49	0.42	−0.21
	2016	0.65	0.14	0.45	0.11	0.50	0.45	−0.20
	2017	0.64	0.12	0.46	0.11	0.47	0.38	−0.18

Table S4. The location information of the 26 major cities used for meteorology evaluation. NE is northeast China, NC is north China, CC is central China, EC is east China, SC is south China, SW indicates southwest China, and NW is northwest China.

City	Lon	Lat	Region	City	Lon	Lat	Region
Haerbin	126.34	45.56	NEC	Hefei	117.18	31.47	EC
Changchun	125.13	43.54	NEC	Shanghai	121.27	31.24	EC
Shenyang	123.31	41.44	NEC	Hangzhou	120.10	30.14	EC
Huhehaote	111.34	40.51	NC	Xiamen	118.04	24.29	EC
Beijing	116.13	39.99	NC	Shenzhen	114.00	23.32	SC
Tianjin	117.21	39.17	NC	Guangzhou	113.29	23.13	SC
Taiyuan	112.35	37.37	NC	Nanning	108.13	22.38	SC
Zhengzhou	113.39	34.43	NC	Haikou	110.15	20.00	SC
Jinan	117.00	36.36	NC	Chongqing	107.22	29.53	SWC
Wuhan	114.03	30.36	CC	Guiyang	106.44	26.35	SWC
Changsha	112.55	28.13	CC	Kunming	102.39	25.00	SWC
Nanchang	115.55	28.36	CC	Yinchuan	106.12	38.28	NWC
Nanjing	118.54	31.56	EC	Xining	101.45	36.44	NWC

Table S5. Evaluation results of surface temperature at 2-m (℃) in 26 major cities from the implemented model. NE is northeast China, NC is north China, CC is central China, EC is east China, SC is south China, SW indicates southwest China, and NW is northwest China. Mean_obs (Mean_simu) is the mean value of observations (model simulations); SD_obs (SD_simu) is the standard deviation of the observations (model simulations); IOA is the index of agreement; CORR is the correlation coefficient; MB is the mean bias.

City	Region	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
Haerbin	NEC	22.58	3.16	22.19	3.21	0.94	0.91	−0.39
Changchun	NEC	22.62	3.22	22.05	3.00	0.94	0.93	−0.57
Shenyang	NEC	23.84	2.79	23.95	2.84	0.94	0.89	0.11
Huhehaote	NC	21.26	2.88	23.52	3.04	0.81	0.88	2.27
Beijing	NC	26.54	2.59	28.25	2.80	0.83	0.86	1.71
Tianjin	NC	26.54	2.52	27.41	2.73	0.90	0.87	0.87
Taiyuan	NC	21.25	2.88	23.52	3.04	0.81	0.88	2.27
Zhengzhou	NC	27.57	2.89	26.66	2.79	0.92	0.91	−1.01
Jinan	NC	26.49	2.81	25.65	2.65	0.90	0.87	−0.84
Wuhan	CC	27.30	2.98	26.53	2.55	0.93	0.90	−0.76
Changsha	CC	27.25	3.08	26.65	2.87	0.92	0.89	−0.60
Nanchang	CC	28.30	3.08	27.42	2.82	0.9	0.85	−0.88
Nanjing	EC	26.76	3.29	26.32	3.00	0.96	0.93	−0.44
Hefei	EC	27.14	3.20	26.38	2.86	0.94	0.93	−0.76
Shanghai	EC	27.09	3.32	25.93	2.82	0.93	0.94	−1.16
Hangzhou	EC	27.60	3.38	26.26	3.00	0.91	0.91	−1.35
Xiamen	EC	28.04	1.75	27.40	1.22	0.77	0.72	−0.63
Shenzhen	SC	29.03	1.39	28.65	0.86	0.65	0.53	−0.39
Guangzhou	SC	28.29	1.55	28.85	1.55	0.75	0.65	0.56
Nanning	SC	28.14	1.63	27.67	1.74	0.82	0.72	−0.47
Haikou	SC	28.93	1.38	29.25	1.06	0.77	0.66	0.31
Chongqing	SWC	26.69	3.24	24.84	2.79	0.83	0.87	−1.84
Guiyang	SWC	22.43	2.15	21.37	2.00	0.82	0.79	−1.06
Kunming	SWC	20.49	1.57	18.63	1.64	0.65	0.75	−1.86
Yinchuan	NWC	23.49	2.97	24.64	3.15	0.93	0.93	1.15

Xining	NWC	16.9	2.77	12.46	2.87	0.60	0.85	−4.44

Table S6. Same as Table S5 but for relative humidity at 2-m (%).

City	Region	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
Haerbin	NEC	72.25	10.52	70.32	15.31	0.86	0.81	−1.78
Changchun	NEC	69.78	12.27	74.89	13.57	0.82	0.78	5.10
Shenyang	NEC	71.26	11.68	70.73	13.02	0.86	0.77	−0.53
Huhehaote	NC	50.52	14.24	49.89	13.02	0.79	0.70	−0.63
Beijing	NC	62.17	14.69	48.05	13.58	0.71	0.77	−14.12
Tianjin	NC	66.37	13.25	55.75	12.44	0.75	0.77	−10.62
Taiyuan	NC	66.72	12.98	57.38	15.03	0.76	0.73	−9.3
Zhengzhou	NC	67.24	14.00	63.76	15.27	0.83	0.72	−3.48
Jinan	NC	66.49	14.48	67.22	15.19	0.88	0.79	0.74
Wuhan	CC	81.20	8.84	85.88	9.27	0.76	0.68	4.68
Changsha	CC	79.40	10.74	90.57	7.12	0.64	0.67	11.17
Nanchang	CC	77.08	10.76	88.42	9.43	0.70	0.79	11.34
Nanjing	EC	78.51	10.83	87.07	9.82	0.77	0.83	8.56
Hefei	EC	79.55	9.68	85.79	11.06	0.82	0.82	6.26
Shanghai	EC	76.98	9.55	89.14	8.31	0.63	0.73	12.16
Hangzhou	EC	76.52	10.88	90.33	7.49	0.63	0.85	13.81
Xiamen	EC	83.09	9.00	91.65	4.89	0.62	0.72	8.56
Shenzhen	SC	79.82	7.54	92.03	3.77	0.50	0.62	12.21
Guangzhou	SC	82.05	6.78	87.39	7.48	0.68	0.61	5.34
Nanning	SC	83.01	5.89	90.25	6.37	0.62	0.63	7.23
Haikou	SC	80.17	5.94	83.95	5.03	0.66	0.55	3.78
Chongqing	SWC	76.28	11.00	88.16	7.34	0.63	0.70	11.86
Guiyang	SWC	82.46	8.64	95.04	3.84	0.52	0.65	12.57
Kunming	SWC	78.03	7.70	93.82	4.21	0.42	0.57	15.79
Yinchuan	NWC	52.63	14.01	42.99	13.70	0.77	0.76	−9.65
Xining	NWC	63.22	12.66	73.97	14.49	0.72	0.75	10.75

Table S7. Same as Table S5 but for wind speed at 10-m (m s^{-1}).

City	Region	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
Haerbin	NEC	2.47	1.16	3.08	1.78	0.75	0.68	0.62
Changchun	NEC	2.30	0.89	3.16	1.91	0.61	0.64	0.86
Shenyang	NEC	1.88	0.74	3.00	1.72	0.50	0.53	1.12
Huhehaote	NC	2.76	0.88	2.46	1.30	0.57	0.41	-0.30
Beijing	NC	1.81	0.59	2.20	1.35	0.52	0.43	0.38
Tianjin	NC	2.09	0.70	2.59	1.27	0.58	0.47	0.49
Taiyuan	NC	2.06	0.81	2.12	1.12	0.66	0.46	0.07
Zhengzhou	NC	1.75	0.54	2.46	1.26	0.48	0.48	0.71
Jinan	NC	1.89	0.81	2.84	1.44	0.61	0.60	0.95
Wuhan	CC	1.79	0.75	2.02	1.25	0.63	0.50	0.23
Changsha	CC	2.15	0.93	2.58	1.47	0.65	0.55	0.45
Nanchang	CC	2.23	0.76	2.55	1.50	0.55	0.48	0.31
Nanjing	EC	2.31	0.96	2.68	1.41	0.72	0.62	0.36
Hefei	EC	1.91	0.66	2.67	1.40	0.61	0.63	0.76
Shanghai	EC	2.36	0.86	3.32	1.84	0.57	0.54	0.97
Hangzhou	EC	2.04	0.61	2.45	1.46	0.53	0.47	0.41
Xiamen	EC	2.29	0.73	3.12	1.58	0.54	0.49	0.83
Shenzhen	SC	1.93	0.91	3.27	1.74	0.47	0.39	1.35
Guangzhou	SC	1.92	0.81	2.38	1.23	0.59	0.44	0.45
Nanning	SC	2.11	0.72	2.75	1.48	0.56	0.51	0.64
Haikou	SC	2.11	0.58	2.85	1.57	0.45	0.39	0.74
Chongqing	SWC	1.92	0.68	2.09	1.24	0.55	0.44	0.17
Guiyang	SWC	2.44	0.81	3.18	1.71	0.59	0.57	0.74
Kunming	SWC	2.13	0.79	2.34	1.24	0.57	0.51	0.21
Yinchuan	NWC	1.76	0.56	2.75	1.36	0.38	0.30	0.99
Xining	NWC	1.16	0.43	3.07	1.40	0.22	0.16	1.91

Table S8. The location information of the 30 major cities used for air pollutants evaluation. NE is northeast China, NC is north China, CC is central China, EC is east China, SC is south China, SW indicates southwest China, and NW is northwest China.

City	Lon	Lat	Region	City	Lon	Lat	Region
Haerbin	126.65	45.74	NEC	Shanghai	121.45	31.21	EC
Changchun	125.35	43.83	NEC	Hangzhou	120.08	30.21	EC
Shenyang	123.44	41.81	NEC	Xiamen	118.12	24.56	EC
Huhehaote	111.67	40.80	NC	Shenzhen	114.16	22.60	SC
Beijing	116.40	40.05	NC	Guangzhou	113.35	23.19	SC
Tianjin	117.32	39.10	NC	Nanning	108.32	22.80	SC
Shijiazhuang	114.50	38.03	NC	Haikou	110.37	20.01	SC
Taiyuan	112.52	37.86	NC	Chengdu	104.01	30.70	SWC
Zhengzhou	113.65	34.78	NC	Chongqing	106.51	29.58	SWC
Jinan	116.98	36.65	NC	Guiyang	106.70	26.54	SWC
Wuhan	114.25	30.54	CC	Kunming	102.71	25.01	SWC
Changsha	112.98	28.21	CC	Yinchuan	106.16	38.49	NWC
Nanchang	115.88	28.68	CC	Xining	101.71	36.65	NWC
Nanjing	118.78	32.06	EC	Lanzhou	103.83	36.05	NWC
Hefei	117.25	31.85	EC	Xi'an	108.99	34.30	NWC

Table S9. Evaluation results of O_3 (ppb) in 30 major cities from the implemented model. NE is northeast China, NC is north China, CC is central China, EC is east China, SC is south China, SW indicates southwest China, and NW is northwest China. Mean_obs (Mean_simu) is the mean value of observations (model simulations); SD_obs (SD_simu) is the standard deviation of the observations (model simulations); IOA is the index of agreement; CORR is the correlation coefficient; MB is the mean bias.

City	Region	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
Haerbin	NEC	29.51	10.84	39.21	15.89	0.74	0.79	9.55
Changchun	NEC	34.68	12.49	44.40	16.93	0.74	0.71	9.68
Shenyang	NEC	38.75	12.22	49.02	17.44	0.67	0.60	9.90
Huhehaote	NC	39.58	9.67	52.91	22.26	0.61	0.74	13.64
Beijing	NC	45.09	14.61	82.16	36.92	0.43	0.64	37.12
Tianjin	NC	39.67	12.58	75.41	31.98	0.41	0.60	35.80
Shijiazhuang	NC	35.73	11.50	76.13	30.20	0.30	0.32	40.69
Taiyuan	NC	35.40	11.95	68.05	24.95	0.43	0.64	32.94
Zhengzhou	NC	40.81	11.23	79.43	24.14	0.37	0.55	38.68
Jinan	NC	47.42	15.00	73.47	26.57	0.54	0.63	25.88
Wuhan	CC	35.06	10.98	42.43	17.23	0.69	0.62	7.55
Changsha	CC	29.44	9.47	52.40	16.10	0.46	0.60	23.11
Nanchang	CC	31.45	10.33	52.61	16.47	0.50	0.61	21.44
Nanjing	EC	35.75	14.83	44.73	20.58	0.70	0.60	8.80
Hefei	EC	30.82	9.29	53.69	21.92	0.45	0.58	22.56
Shanghai	EC	40.14	13.60	42.34	21.29	0.77	0.68	2.84
Hangzhou	EC	33.10	12.70	47.11	20.55	0.62	0.60	14.09
Xiamen	EC	23.23	7.11	22.73	13.34	0.72	0.73	−0.24
Shenzhen	SC	21.30	8.80	26.83	15.68	0.74	0.75	5.59
Guangzhou	SC	23.96	11.55	34.46	16.80	0.67	0.62	10.75
Nanning	SC	21.83	7.09	36.10	9.84	0.49	0.60	14.38
Haikou	SC	17.94	5.44	38.29	11.70	0.33	0.58	20.77
Chengdu	SWC	34.47	10.49	52.48	15.95	0.48	0.44	18.06
Chongqing	SWC	28.04	10.66	50.50	17.74	0.47	0.54	22.59
Guiyang	SWC	23.37	7.03	36.74	11.15	0.50	0.56	13.67
Kunming	SWC	23.07	9.41	29.63	10.41	0.71	0.65	6.93
Yinchuan	NWC	37.98	9.77	45.79	16.26	0.60	0.51	7.95
Xining	NWC	33.67	8.04	46.29	12.31	0.48	0.39	12.64
Lanzhou	NWC	31.07	7.24	45.01	10.69	0.43	0.33	14.03
Xi'an	NWC	35.83	9.89	62.31	15.65	0.41	0.50	26.64

Table S10. Same for Table S9 but for PM$_{2.5}$ (μg m^{-3}).

City	Region	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
Haerbin	NEC	27.61	15.73	29.64	15.56	0.61	0.46	1.88
Changchun	NEC	32.25	17.12	41.62	18.63	0.60	0.50	9.10
Shenyang	NEC	36.64	15.79	48.46	19.35	0.59	0.46	11.51
Huhehaote	NC	24.72	12.70	33.57	14.00	0.69	0.60	9.15
Beijing	NC	57.32	34.04	63.16	33.56	0.76	0.62	6.60
Tianjin	NC	52.70	21.88	69.74	26.38	0.60	0.47	17.29
Shijiazhuang	NC	63.17	30.31	79.08	31.86	0.63	0.51	16.88
Taiyuan	NC	45.38	20.08	57.07	22.46	0.65	0.50	12.35
Zhengzhou	NC	53.70	20.01	75.15	28.17	0.51	0.40	22.22
Jinan	NC	59.41	21.22	71.71	27.65	0.57	0.39	12.82
Wuhan	CC	39.00	18.66	119.54	51.38	0.23	0.23	79.72
Changsha	CC	38.17	19.58	71.13	36.26	0.32	0.17	33.01
Nanchang	CC	26.53	14.82	52.86	26.55	0.30	0.06	26.68
Nanjing	EC	39.60	21.41	97.02	42.29	0.37	0.40	56.94
Hefei	EC	45.70	22.23	88.54	37.62	0.36	0.25	42.70
Shanghai	EC	37.60	20.15	53.74	36.41	0.67	0.65	16.56
Hangzhou	EC	36.80	15.73	78.62	37.11	0.34	0.33	42.22
Xiamen	EC	20.31	9.07	33.12	15.13	0.54	0.58	13.29
Shenzhen	SC	17.55	10.23	23.79	16.02	0.72	0.67	6.48
Guangzhou	SC	28.37	12.04	39.84	16.85	0.55	0.43	11.94
Nanning	SC	23.58	12.48	23.19	15.26	0.55	0.31	−0.01
Haikou	SC	12.89	5.09	12.51	7.12	0.73	0.60	−0.10
Chengdu	SWC	38.90	17.04	81.81	23.00	0.35	0.25	43.26
Chongqing	SWC	35.57	11.67	99.64	55.52	0.17	0.10	64.97
Guiyang	SWC	24.73	11.45	46.55	24.40	0.40	0.37	22.00
Kunming	SWC	20.58	7.95	43.50	16.38	0.27	0.09	23.50
Yinchuan	NWC	37.58	12.57	36.18	10.60	0.52	0.26	−1.07
Xining	NWC	34.43	9.97	35.40	7.83	0.43	0.10	1.01
Lanzhou	NWC	40.08	11.20	38.44	10.74	0.42	0.10	−1.67
Xi'an	NWC	37.54	14.21	51.39	22.44	0.29	−0.06	14.56

Table S11. Same for Table S9 but for PM$_{10}$ (µg m^{-3}).

City	Region	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
Haerbin	NEC	49.97	22.28	33.43	16.39	0.48	0.23	−16.69
Changchun	NEC	64.85	26.37	46.96	20.01	0.57	0.37	−18.17
Shenyang	NEC	65.87	24.76	55.69	21.29	0.58	0.37	−10.48
Huhehaote	NC	73.91	34.15	35.23	14.74	0.48	0.32	−38.35
Beijing	NC	77.62	34.51	69.73	35.62	0.66	0.47	−12.22
Tianjin	NC	86.85	29.80	77.05	27.91	0.57	0.32	−9.62
Shijiazhuang	NC	112.95	43.39	89.21	33.36	0.57	0.38	−22.72
Taiyuan	NC	92.85	33.83	64.29	24.10	0.53	0.33	−27.86
Zhengzhou	NC	106.03	38.35	85.01	29.74	0.53	0.25	−20.24
Jinan	NC	109.76	36.25	79.76	28.80	0.50	0.24	−29.46
Wuhan	CC	75.09	33.90	146.68	55.86	0.32	0.10	70.72
Changsha	CC	60.95	25.17	78.86	37.25	0.35	0.02	17.95
Nanchang	CC	58.92	27.94	59.00	27.19	0.32	-0.11	0.49
Nanjing	EC	67.36	31.43	110.38	44.53	0.43	0.24	42.44
Hefei	EC	75.26	32.05	101.85	39.47	0.38	0.07	26.55
Shanghai	EC	53.28	24.10	61.88	39.24	0.65	0.51	6.67
Hangzhou	EC	58.97	23.13	89.18	38.61	0.41	0.23	30.61
Xiamen	EC	38.16	15.05	41.73	16.40	0.64	0.46	4.01
Shenzhen	SC	33.21	14.04	31.00	17.64	0.75	0.63	−1.92
Guangzhou	SC	46.43	15.72	49.09	17.91	0.59	0.36	3.18
Nanning	SC	47.81	22.05	25.27	15.88	0.43	0.20	−22.20
Haikou	SC	28.74	8.36	14.45	7.43	0.48	0.47	−13.99
Chengdu	SWC	67.66	28.12	95.59	24.48	0.45	0.22	28.31
Chongqing	SWC	60.32	18.46	116.20	59.89	0.19	-0.11	56.90
Guiyang	SWC	46.40	18.07	50.72	25.52	0.49	0.22	4.50
Kunming	SWC	42.19	15.16	48.03	17.26	0.36	0.03	6.45
Yinchuan	NWC	85.20	29.22	39.92	11.06	0.41	0.01	−45.23
Xining	NWC	71.24	28.07	41.86	8.21	0.36	-0.14	−29.35
Lanzhou	NWC	92.69	31.45	41.43	10.99	0.39	-0.03	−51.28
Xi'an	NWC	82.08	29.32	58.34	23.75	0.26	-0.26	−23.00

Table S12. Same for Table S9 but for SO$_2$ (ppb).

City	Region	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
Haerbin	NEC	2.89	0.83	2.73	1.47	0.49	0.30	−0.14
Changchun	NEC	2.90	0.90	4.33	2.51	0.41	0.42	1.49
Shenyang	NEC	5.78	2.50	7.75	4.32	0.55	0.43	2.04
Huhehaote	NC	4.91	1.78	1.77	1.52	0.47	0.48	−3.12
Beijing	NC	1.67	1.16	6.31	3.60	0.30	0.47	4.67
Tianjin	NC	4.42	2.14	9.50	4.23	0.34	0.26	5.05
Shijiazhuang	NC	7.04	3.53	11.95	3.79	0.53	0.49	4.99
Taiyuan	NC	8.48	4.01	8.85	4.72	0.69	0.53	0.47
Zhengzhou	NC	4.73	2.45	7.77	3.14	0.60	0.58	3.04
Jinan	NC	9.86	3.58	10.07	4.09	0.60	0.55	0.21
Wuhan	CC	4.11	1.18	38.60	12.06	0.05	0.06	34.57
Changsha	CC	5.08	1.52	4.53	2.72	0.66	0.59	−0.49
Nanchang	CC	6.97	2.61	2.67	1.74	0.54	0.57	−4.24
Nanjing	EC	5.16	2.00	8.62	3.74	0.52	0.60	3.37
Hefei	EC	3.98	1.15	4.71	2.14	0.47	0.46	0.70
Shanghai	EC	3.85	1.07	11.19	5.15	0.22	0.57	7.39
Hangzhou	EC	3.51	1.04	6.35	2.25	0.36	0.41	2.86
Xiamen	EC	4.28	1.63	5.83	1.95	0.53	0.48	1.60
Shenzhen	SC	2.75	0.59	5.98	2.39	0.27	0.65	3.27
Guangzhou	SC	4.42	1.12	7.17	2.75	0.32	0.25	2.75
Nanning	SC	3.41	0.78	0.89	0.66	0.31	0.65	−2.54
Haikou	SC	1.99	0.48	1.86	0.67	0.62	0.45	−0.11
Chengdu	SWC	4.36	1.35	16.35	4.69	0.14	0.16	12.09
Chongqing	SWC	4.01	1.28	37.89	13.02	0.04	-0.27	34.19
Guiyang	SWC	2.75	0.90	2.91	1.33	0.54	0.47	0.15
Kunming	SWC	5.46	2.41	2.35	0.91	0.46	0.31	−3.11
Yinchuan	NWC	6.90	2.92	5.27	1.56	0.56	0.39	−1.63
Xining	NWC	7.87	3.92	2.76	0.76	0.46	0.32	−5.10
Lanzhou	NWC	4.57	1.78	2.49	0.89	0.49	0.32	−2.07
Xi'an	NWC	3.47	1.20	6.31	2.35	0.36	0.34	2.88

Table S13. Same for Table S9 but for NO$_2$ (ppb).

City	Region	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
Haerbin	NEC	16.92	4.48	10.94	3.53	0.43	0.15	−5.96
Changchun	NEC	18.41	5.53	12.63	4.60	0.45	0.17	−5.79
Shenyang	NEC	16.73	4.59	16.94	7.15	0.44	0.13	0.26
Huhehaote	NC	16.33	4.03	2.70	1.20	0.32	0.34	−13.63
Beijing	NC	17.90	4.04	12.59	4.77	0.53	0.40	−5.31
Tianjin	NC	16.38	5.15	18.89	8.21	0.45	0.19	2.42
Shijiazhuang	NC	16.75	5.60	20.20	4.44	0.54	0.32	3.51
Taiyuan	NC	18.93	4.63	9.35	3.54	0.43	0.39	−9.53
Zhengzhou	NC	19.77	5.79	15.91	4.40	0.63	0.48	−3.87
Jinan	NC	17.34	4.93	15.39	3.03	0.48	0.20	−1.88
Wuhan	CC	18.09	5.34	45.34	10.56	0.26	0.45	27.24
Changsha	CC	12.96	3.18	11.29	4.38	0.45	0.16	−1.64
Nanchang	CC	12.14	3.39	8.19	4.08	0.43	0.17	−3.85
Nanjing	EC	17.26	4.45	35.08	8.33	0.28	0.35	17.56
Hefei	EC	14.25	3.69	23.09	5.28	0.32	0.10	8.77
Shanghai	EC	15.76	5.58	22.91	10.62	0.60	0.67	7.36
Hangzhou	EC	16.27	4.13	30.89	6.75	0.33	0.50	14.71
Xiamen	EC	12.44	4.09	20.29	4.24	0.48	0.52	7.94
Shenzhen	SC	13.60	3.88	18.61	6.48	0.64	0.72	5.10
Guangzhou	SC	18.14	4.60	24.73	7.64	0.32	-0.06	6.63
Nanning	SC	12.58	3.32	3.71	1.10	0.35	0.34	−8.91
Haikou	SC	7.47	2.04	4.23	1.28	0.54	0.67	−3.19
Chengdu	SWC	22.64	6.07	32.26	6.48	0.45	0.32	9.73
Chongqing	SWC	16.85	3.88	25.82	7.15	0.28	0.00	9.16
Guiyang	SWC	12.21	3.00	6.38	2.25	0.42	0.30	−5.87
Kunming	SWC	12.73	2.92	10.85	2.46	0.41	0.08	−1.91
Yinchuan	NWC	13.66	4.29	8.66	1.90	0.49	0.29	−4.97
Xining	NWC	15.84	4.23	8.96	1.50	0.39	0.16	−6.89
Lanzhou	NWC	21.33	6.37	6.24	1.75	0.39	0.34	−15.10
Xi'an	NWC	18.34	4.91	12.63	2.96	0.44	0.06	−5.66

Table S14. Same for Table S9 but for CO (ppm).

City	Region	Mean_obs	SD_obs	Mean_simu	SD_simu	IOA	CORR	MB
Haerbin	NEC	0.60	0.13	0.32	0.09	0.42	0.49	−0.28
Changchun	NEC	0.61	0.13	0.37	0.1	0.49	0.57	−0.24
Shenyang	NEC	0.65	0.20	0.44	0.12	0.58	0.59	−0.21
Huhehaote	NC	0.65	0.16	0.22	0.07	0.35	0.46	−0.43
Beijing	NC	0.67	0.22	0.52	0.18	0.68	0.58	−0.15
Tianjin	NC	0.88	0.25	0.56	0.18	0.50	0.36	−0.32
Shijiazhuang	NC	0.66	0.20	0.67	0.16	0.61	0.41	0.01
Taiyuan	NC	0.88	0.21	0.43	0.12	0.42	0.39	−0.45
Zhengzhou	NC	0.92	0.18	0.54	0.12	0.43	0.48	−0.38
Jinan	NC	0.84	0.21	0.50	107.33	0.44	0.28	−0.34
Wuhan	CC	0.69	0.16	0.86	185.96	0.44	0.19	0.17
Changsha	CC	0.62	0.12	0.49	115.36	0.62	0.59	−0.13
Nanchang	CC	0.76	0.14	0.40	100.50	0.35	0.23	−0.36
Nanjing	EC	0.68	0.15	0.68	159.70	0.70	0.54	0.00
Hefei	EC	0.67	0.15	0.55	118.06	0.61	0.47	−0.12
Shanghai	EC	0.57	0.13	0.46	201.93	0.72	0.76	−0.11
Hangzhou	EC	0.61	0.11	0.57	127.97	0.70	0.54	−0.04
Xiamen	EC	0.40	0.10	0.36	68.35	0.69	0.63	−0.04
Shenzhen	SC	0.62	0.09	0.34	109.18	0.37	0.62	−0.28
Guangzhou	SC	0.66	0.10	0.47	96.83	0.42	0.28	−0.19
Nanning	SC	0.66	0.09	0.26	67.07	0.27	0.37	-0.4
Haikou	SC	0.46	0.09	0.23	63.76	0.38	0.40	−0.23
Chengdu	SWC	0.73	0.14	0.63	97.18	0.51	0.21	−0.1
Chongqing	SWC	0.70	0.11	0.59	163.36	0.53	0.36	−0.11
Guiyang	SWC	0.49	0.10	0.36	106.94	0.58	0.56	−0.13
Kunming	SWC	0.64	0.12	0.32	48.26	0.35	0.27	−0.32
Yinchuan	NWC	0.70	0.22	0.22	46.61	0.37	0.07	−0.48
Xining	NWC	0.79	0.18	0.22	30.69	0.31	0.18	−0.57
Lanzhou	NWC	0.75	0.17	0.21	39.52	0.31	0.11	−0.54
Xi'an	NWC	0.88	0.14	0.41	87.75	0.32	0.40	−0.47

Table S15. Summary of previous studies about O_3 damage effect.

Study Domain	Simulation Period	Model	Results	References
The Whole Globe	2002–2009	CLM4.5SP (offline)	GPP (−): 8–12% TR (−): 2–2.4%	Lombardozzi et al. (2015)
	2000–2020 JJA	CESM v1.2.2 (online)	LAI (−): less than 5% TR (−): 6.4% T_2 (+): up to 2.0 °C O_3 (+): 4−6 ppb	Sadiq et al. (2017)
	2000–2022	CESM v1.1.1	LH (−): larger than 4% T_2 (+): up to 1.5 °C	Arnold et al. (2018)
	20 years	NASA ModelE2-YIBs	O_3 (+): 2.1 ppb (Eastern China), 1.6 ppb (Eastern U.S.), 1.3 ppb (Western Europe)	Gong et al. (2020)
The United States	1998–2007	YIBs	GPP (−): 11–17%	Yue and Unger, 2014
	2007–2012 May 1 to September 30	WRF-Chem v3.7.1	LH (−): 10–27 W m^{-2} T_2 (+): 0.6–2.0 °C Rainfall (−): 0.9–1.4 mm d^{-1} Runoff (−): 0.1–0.17 mm d^{-1}	Li et al. (2016)
	2009–2014 June-September	WRF-Chem v3.9	LH (−): 9–11 W m^{-2} T_2 (+): 0.6–0.7 °C Rainfall (−):0.15-0.21 mm d^{-1} GPP (−): 30–38%	Li et al. (2018)
India	2005	WRF-Chem v3.2.2	Crop Yield (−): 2.1–5.3%	Ghude et al. (2014)
China	2010	NASA ModelE2-YIBs	NPP (−): 14%	Yue et al. (2017)
	Oct 2012–Dec 2013	RegCM-CHEM4-YIBs	GPP (−):12.1 ± 4.4% (up to 35% in summer)	Xie et al. (2019)

Note: "+" means increase, "–" means decrease