Supplement of

Unexpected enhancement of ozone exposure and health risks during the Chinese National Day Holiday

Peng Wang et al.

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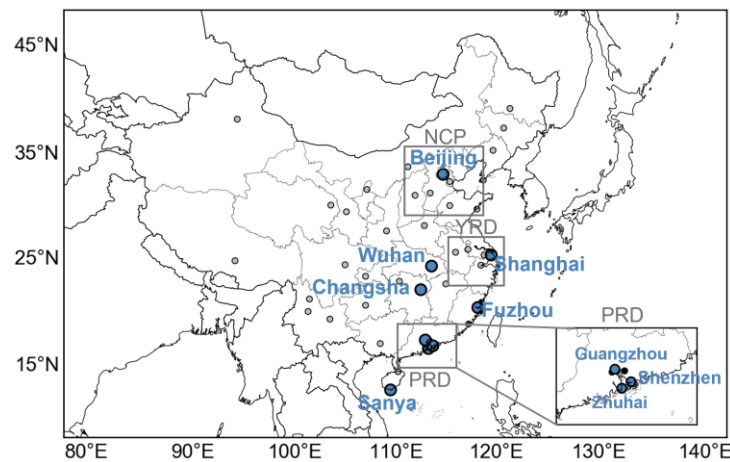
Figure S1 Model domain and city locations. Blue dots represent nine key cities and grey dots refer to other cities.
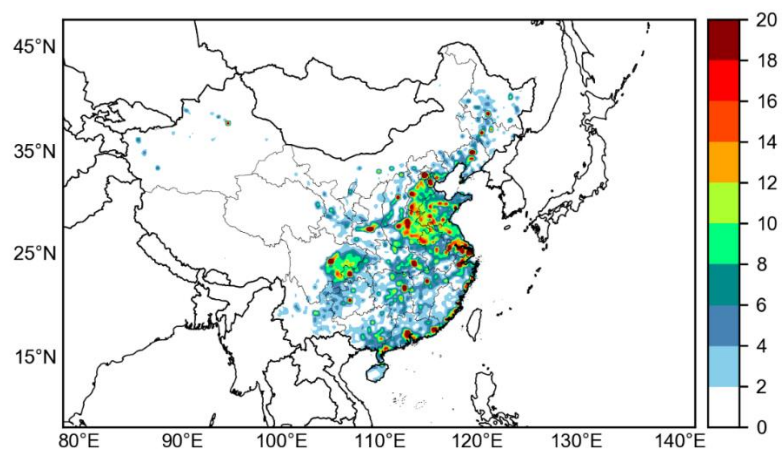
Figure S2 Chinese population ($\times 10^5$) from China's Sixth Census data

(http://www.stats.gov.cn/tjsj/pcsj/rkpc/6rp/indexch.htm).
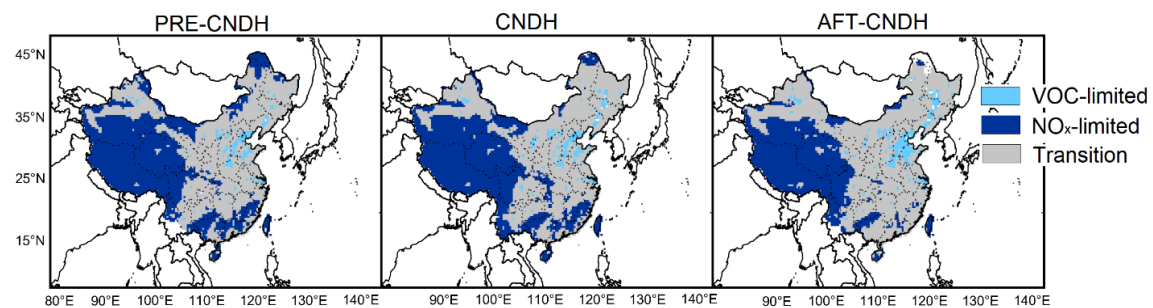
Figure S3 O_3 sensitivity regimes in PRE-CNDH, CNDH, and AFT-CNDH in 2018.
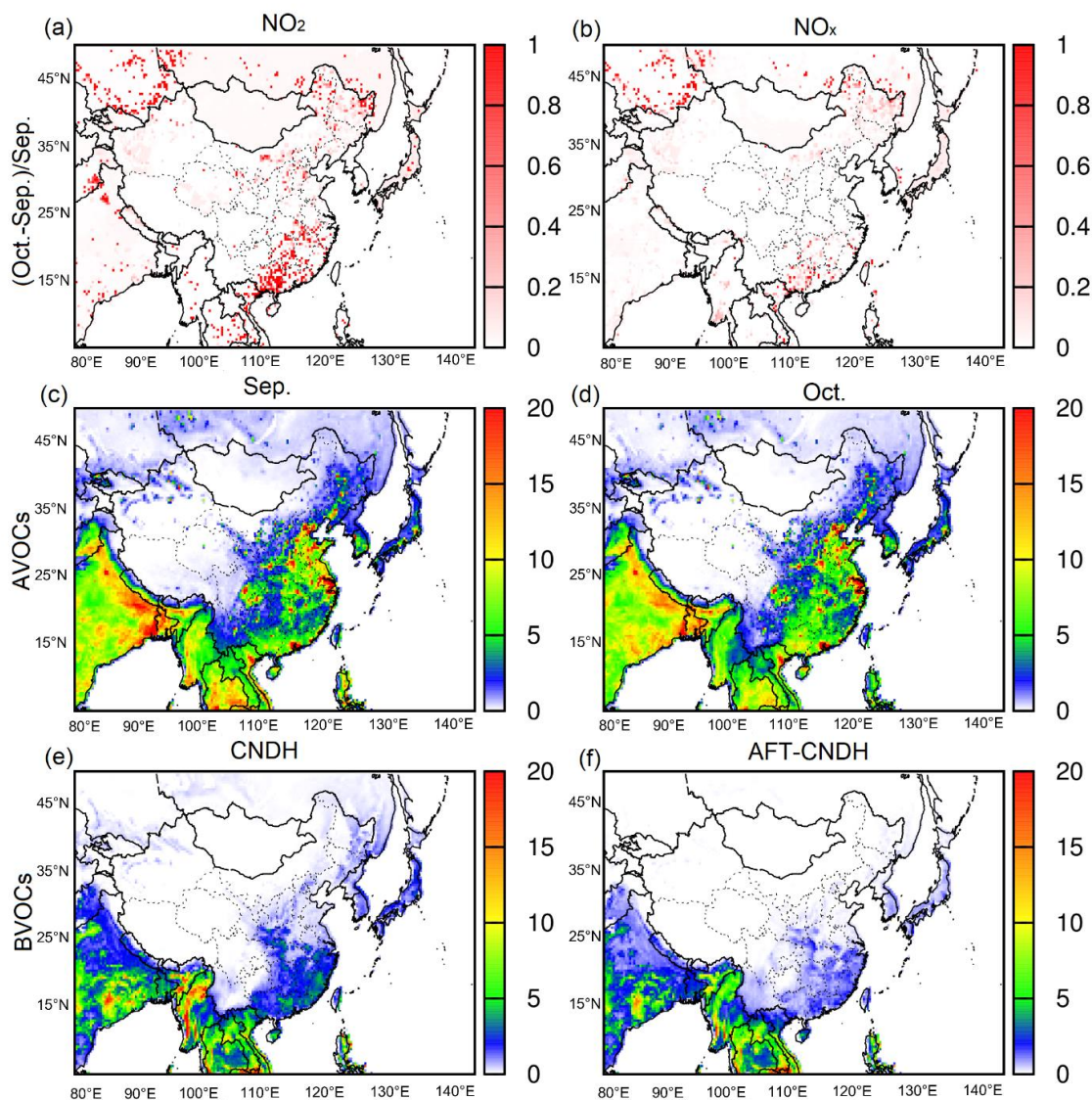
Figure S4 Changes of emissions in relative differences ((Oct.-Sep.)/Sep.) of (a) NO$_2$ and (b)

NO$_x$. Averaged emissions rates of AVOCs from MEIC emission inventory in (c) September and

(d) October. Averaged BVOC emission rates from the MEGAN model in (e) CNDH and (f) AFT-

CNDH. Units are moles/s for (c)-(f).
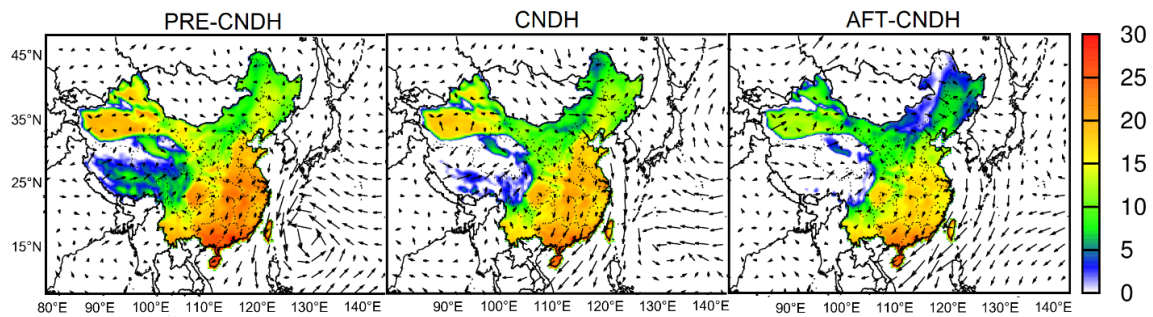
Figure S5 Averaged temperature (in °C) in PRE-CNDH, CNDH, and AFT-CNDH, respectively.

The black arrows show the wind vectors.
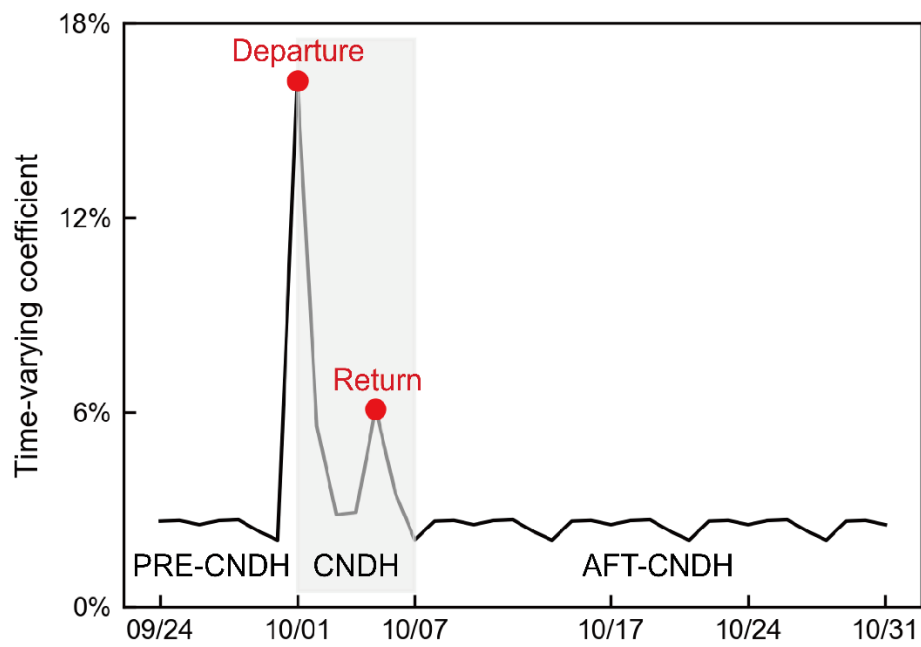
Figure S6 Time-varying coefficient of traffic flow during the PRE-CNDH, CNDH and AFT-CNDH.
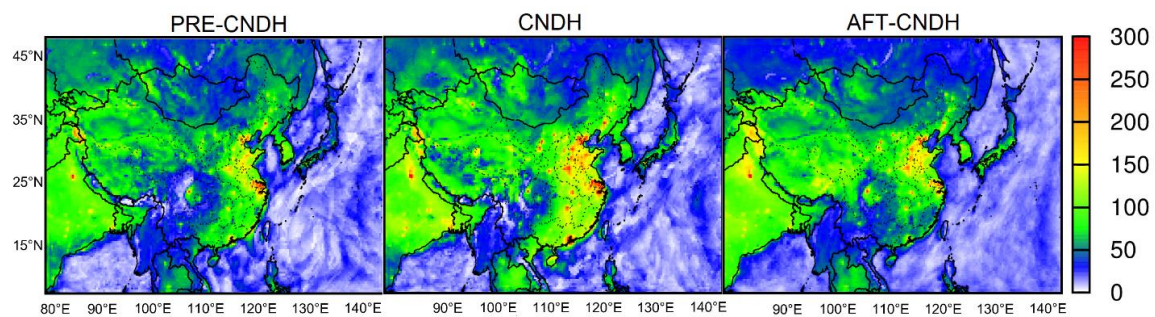
Figure S7 Predicted MDA8 O$_3$ production rates in PRE-CNDH, CNDH and AFT-CNDH, respectively. Units are ppb h^{-1}.
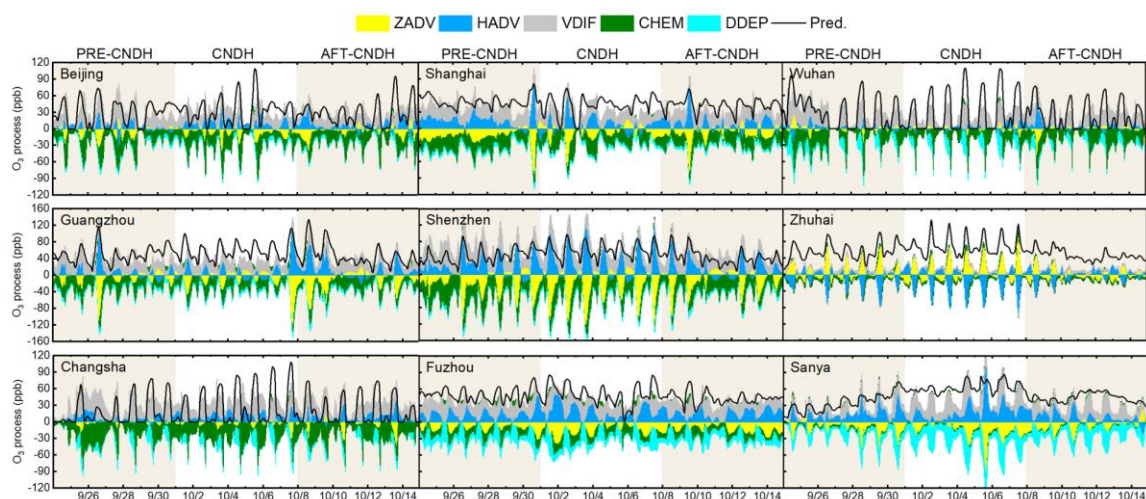
Figure S8 O₃ process analysis in nine key cities during the CNDH in 2018.
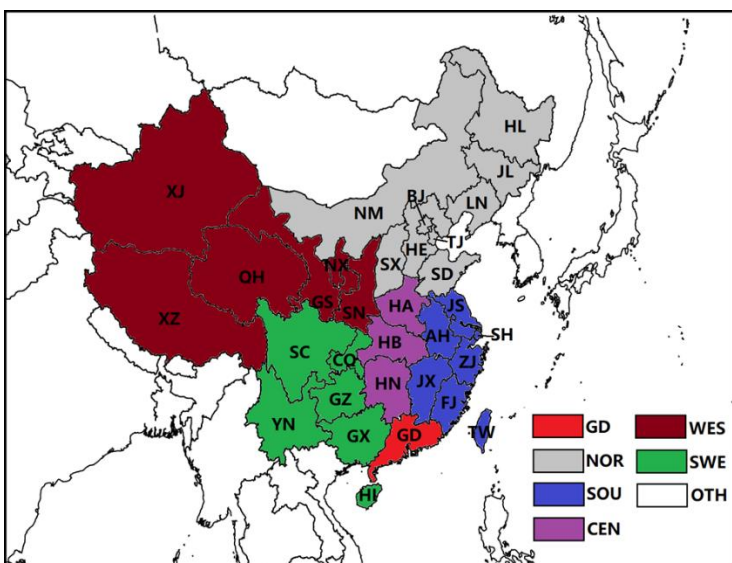
Figure S9 The categories of regional source sectors for the PRD simulations. Regions in same color are defined as the same region group. The regional categories are: GD: Guangdong (including Guangdong province); NOR: northern part (including the BTH and the northeast); SOU: Southern part (mainly including the YRD); CEN: central part (including Hunan, Hubei, and Henan provinces); WES: western part (mainly including Shaanxi, Gansu, and Xinjiang

provinces); SWE: (southeast part mainly including Sichuan, Yunnan and Guangxi provinces);

OTH: Other countries. The full names of the provinces are listed in **Table S7**.
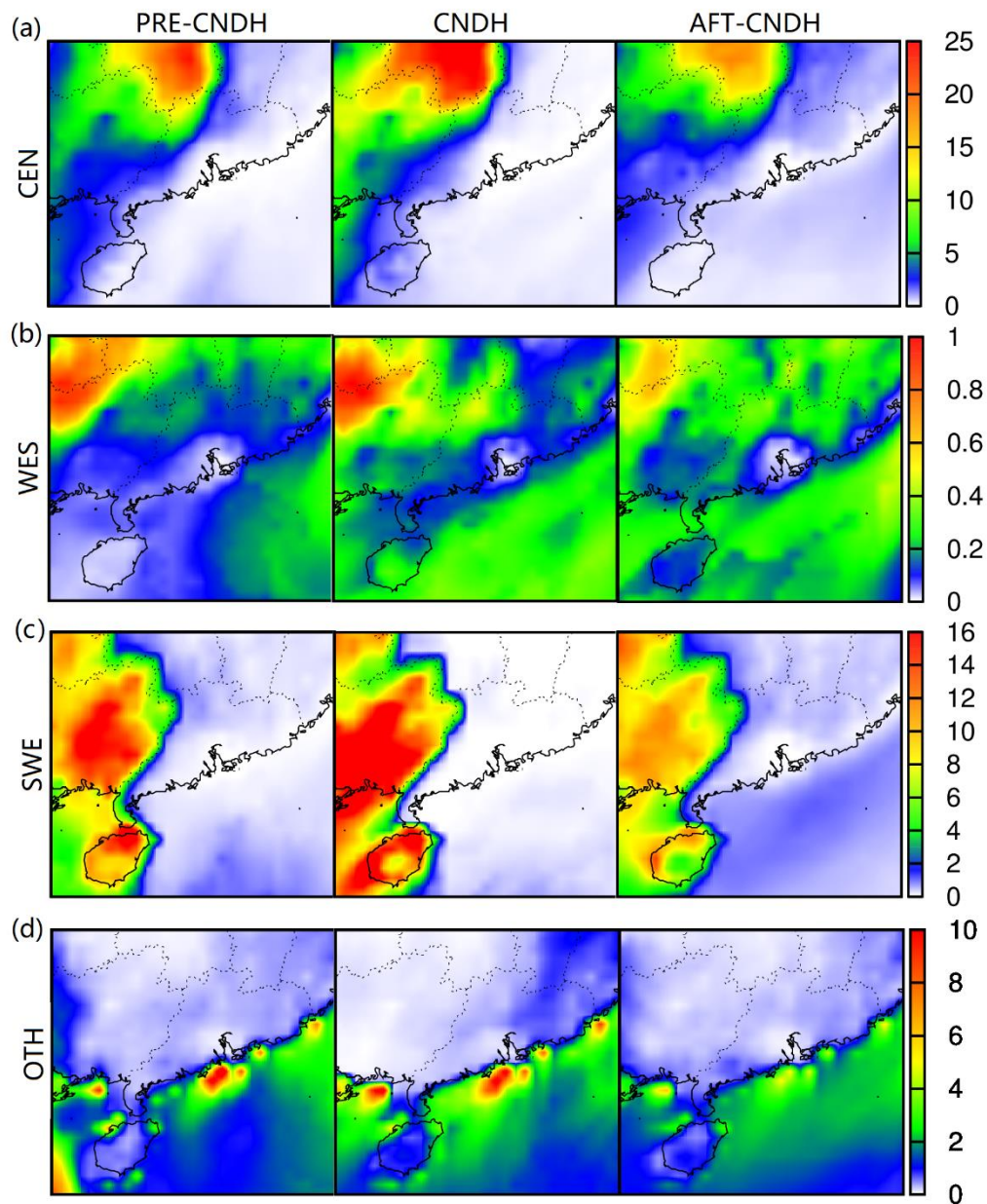
Figure S10 The same figure as Figure 4 (a) but from other sectors to the non-background O_3 in the PRD.
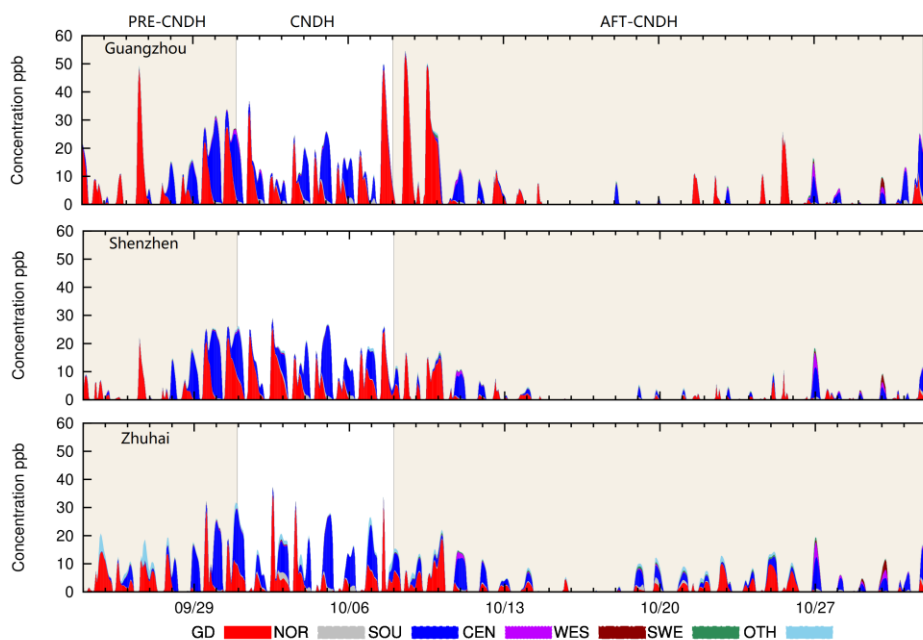
Figure S11 Hourly variations of the contributions of the source regions to $O_3\_NO_x$ in the PRD key cities (Guangzhou, Shenzhen, and Zhuhai).
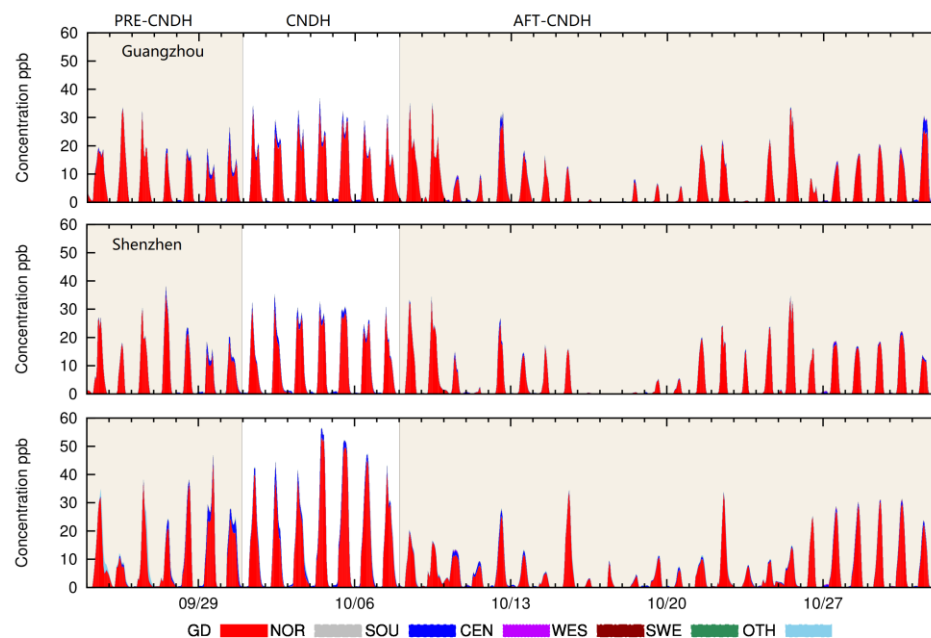
Figure S12 Hourly variations of the contributions of the source regions to O_3_VOC in the PRD key cities (Guangzhou, Shenzhen, and Zhuhai).
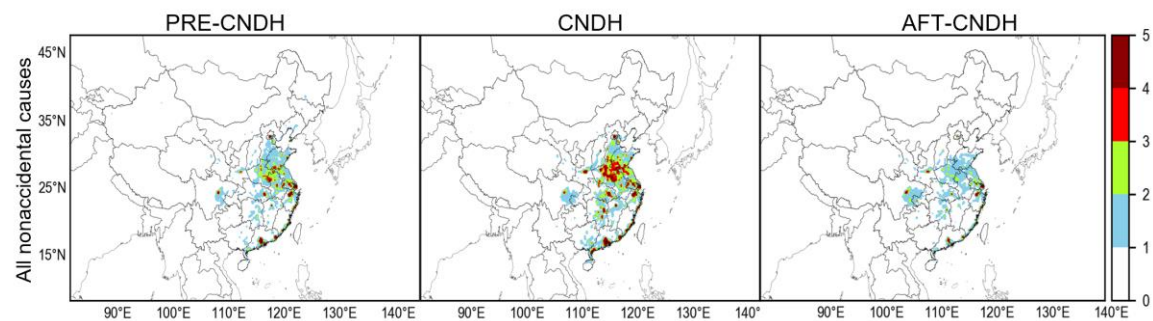
Figure S11 Daily mortality from all non-accidental causes due to O$_3$ during the PRE-CNDH, CNDH and AFT-CNDH in China.

Table S1 Emission profiles of major anthropogenic sectors in September and October.

	Industry	Residential	Transportation	Power
Ratio[*]	0.98	0.82	1	1

[*]: Ratio = emissions in September / emissions in October

Table S2 Seven physical and chemical processes given by the IPR analysis.

Process	Abbreviation
Horizontal advection	HADV
Vertical advection	ZADV
Vertical diffusion	VDIF
Emissions contribution	EMIS
Dry deposition	DDEP
Aerosol processes	AERO
Net sum of all gas-phase chemical processes	CHEM

Table S3 MDA8 O_3 concentrations in PRE-CNDH, CNDH and AFT-CNDH in the 43 cities. The 9 key cities are shown in bold. SC, EC, NC, WC represent South China, East China, North China and West China.

City	PRE-CDNH	CNDH	AFT-CNDH	Max-CNDH*	Exc-CNDH*	Region	Location
Guangzhou	50.6	76.8	41.1	83.2	5		113.3°E, 23.1°N
Shenzhen	52.3	82.7	47.1	92.3	6		114.1°E, 22.6°N
Zhuhai	65.2	97.8	58.6	107.0	7	SC	113.6°E, 22.3°N
Changsha	47.5	80.8	42.6	99.8	5		112.9°E, 28.2°N
Sanya	33.5	73.5	41.9	85.9	4		109.5°E, 18.3°N
Shanghai	58.3	63.2	48.7	87.0	1		121.5°E, 31.2°N
Wuhan	56.6	73.6	42.8	88.5	4	EC	114.3°E, 30.6°N
Fuzhou	56.4	70.1	49.1	81.9	2		119.3°E, 26.1°N
Beijing	35.7	41.3	30.5	58.1	0	NC	116.4°E, 39.9°N
Foshan	55.7	85.1	42.9	97.8	7		113.1°E, 23.0°N
Haikou	37.9	78.8	43.6	89.4	5		110.3°E, 20.0°N
Nanning	34.3	69.0	27.4	82.1	1		108.4°E, 22.8°N
Dongguan	54.9	72.9	47.2	77.5	1	SC	113.8°E, 23.1°N
Zhangjiajie	46.4	53.2	40.3	71.4	0		110.5°E, 29.1°N
Dalizhou	28.2	32.5	31.1	38.6	0		100.2°E, 25.6°N
Lijiang	22.3	30.0	31.2	36.6	0		100.2°E, 26.9°N
Kunming	22.1	27.7	25.7	35.6	0		102.7°E, 25.1°N
Hefei	62.7	74.9	44.3	103.1	3		117.3°E, 31.8°N
Nanjing	60.3	72.6	47.5	97.1	2		118.8°E, 32.1°N
Suzhou	56.6	65.7	44.3	91.1	2	EC	120.6°E, 31.3°N
Nanchang	60.7	78.1	42.5	87.2	5		115.9°E, 28.7°N
Hangzhou	61.8	72.3	44.2	84.5	3		120.2°E, 30.3°N
Xiamen	55.9	65.6	50.0	72.5	0		118.1°E, 24.5°N
Yinchuan	44.6	43.1	40.1	57.0	0		106.3°E, 38.5°N
Guiyang	32.6	35.6	26.8	50.5	0		106.6°E, 26.7°N
Lasa	39.9	46.9	43.1	49.7	0		91.1°E, 29.7°N
Xi'an	31.7	38.3	31.6	49.7	0		108.9°E, 34.3°N
Lanzhou	38.6	41.5	34.0	49.4	0	WC	103.8°E, 36.1°N
Urumqi	33.2	33.9	24.2	47.2	0		87.6°E, 43.8°N
Xining	39.5	41.4	33.2	45.0	0		101.8°E, 36.6°N
Chengdu	34.0	25.7	25.4	32.5	0		104.1°E, 30.7°N
Chongqing	18.0	14.1	15.5	17.7	0		106.6°E, 29.6°N
Jinan	53.3	58.1	43.1	95.3	2		117.0°E, 36.7°N
Tianjin	40.7	50.4	36.3	85.0	2		117.2°E, 39.1°N
Zhengzhou	48.0	58.9	40.6	79.6	2		113.6°E, 34.8°N
Shijiazhuang	40.3	50.6	33.3	72.6	0		114.5°E, 38.1°N
Qingdao	48.6	54.1	42.8	70.0	0		120.4°E, 36.1°N
Dalian	52.5	50.4	43.5	66.7	0	NC	121.6°E, 38.9°N
Taiyuan	40.2	44.3	33.2	64.8	0		112.6°E, 37.9°N
Shenyang	28.7	36.9	31.1	50.7	0		123.4°E, 41.8°N
Haerbin	27.4	33.9	27.2	50.6	0		126.6°E, 45.8°N
Hohhot	30.6	33.3	32.6	47.0	0		111.7°E, 40.8°N
Changchun	23.4	29.7	25.9	41.8	0		125.3°E, 43.9°N

*: Max-CNDH is the maximum MDA8 O_3 and Exc-CNDH refers to days exceeding the air quality standard during CNDH.

Table S4 Meteorological WRF mode performance in the simulation period (Sep. 24 to Oct. 31,

2018). T2: temperature, WS: wind speed, WD: wind direction, RH: relative humidity.

			Benchmark*
T2 (K)	OBS	286.5	
	PRE	286.1	
	MB	-0.4	$\leq\pm0.5$
	GE	2.5	≤2.0
	RMSE	3.3	
WS (m s^{-1})	OBS	3.4	
	PRE	3.9	
	MB	0.5	$\leq\pm0.5$
	GE	1.5	≤2.0
	RMSE	1.9	≤2.0
WD (°)	OBS	178.2	
	PRE	174.0	
	MB	-4.2	$\leq\pm10$
	GE	43.8	$\leq\pm30$
	RMSE	60.6	
RH (%)	OBS	69.6	
	PRE	70.2	
	MB	0.6	
	GE	12.9	
	RMSE	16.5	

*: suggested by Emery et al. (2001)

Table S5 CMAQ model performances of key pollutants in the simulation period (Sep. 24 to Oct. 31, 2018).

			Criteria[*]
O_3-1h (ppb)	OBS	53.71	
	PRE	50.60	
	MFB	-0.16	
	MFE	0.32	
	MNB	-0.07	$\leq\pm0.15$
	MNE	0.26	≤0.3
NO_2 (ppb)	OBS	15.44	
	PRE	12.66	
	MFB	-0.39	
	MFE	0.74	
	MNB	-0.02	
	MNE	0.71	
CO (ppm)	OBS	0.59	
	PRE	0.33	
	MFB	-0.60	
	MFE	0.72	
	MNB	-0.35	
	MNE	0.54	
$PM_{2.5}$ ($\mu g\ m^{-3}$)	OBS	38.80	
	PRE	32.13	
	MFB	-0.04	$\leq\pm0.6$
	MFE	0.59	≤0.75
	MNB	0.17	
	MNE	0.70	

*: suggested by *(EPA, 2005, 2007)*

Table S6 Daily y_0 and β values for all non-accidental causes, cardiovascular diseases (CVD), respiratory diseases (RD), hypertension, stroke and chronic obstructive pulmonary disease (COPD).

Disease	Daily y_0	β (%)
All non-accidental causes	1.687×10^{-5}	0.24
CVD	3.880×10^{-6}	0.27
RD	1.841×10^{-6}	0.18
Hypertension	5.422×10^{-7}	0.60
Stroke	1.197×10^{-7}	0.29
COPD	1.623×10^{-6}	0.20

Table S7 Province names and their abbreviations

Province	Abbreviation	Province	Abbreviation
Beijing	BJ	Henan	HA
Tianjin	TJ	Hubei	HB
Hebei	HE	Hunan	HN
Shanxi	SX	Guangdong	GD
Inner Mongolia	NM	Guangxi	GX
Liaoning	LN	Hainan	HI
Jilin	JL	Chongqing	CQ
Heilongjiang	HL	Sichuan	SC
Shanghai	SH	Guizhou	GZ
Jiangsu	JS	Yunnan	YN
Zhejiang	ZJ	Xizang	XZ
Anhui	AH	Shaanxi	SN
Fujian	FJ	Gansu	GS
Jiangxi	JX	Qinghai	QH
Shandong	SD	Ningxia	NX
Henan	HA	Xinjiang	XJ
Hubei	HB	Taiwan	TW

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EPA, U.: Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS, EPA-454/R-05-002, 2005.
EPA, U.: Guidance on the use of models and other analyses for demonstrating attainment of air quality goals for ozone, PM2. 5, and regional haze, US Environmental Protection Agency, Office of Air Quality Planning and Standards, 2007.