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Fast climate responses to emission reductions in aerosol and ozone precursors in China during 2013–2017

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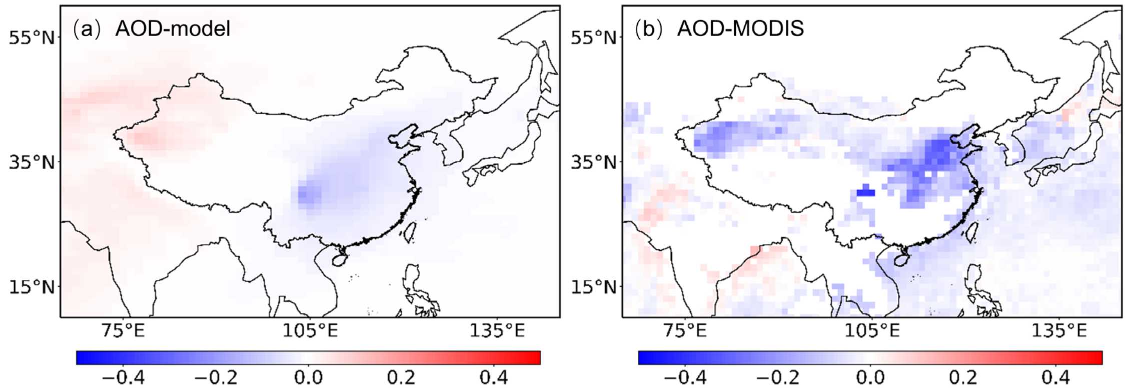

Figure S1. Spatial distributions of annual mean aerosol optical depth (AOD) differences from CESM2 simulations (a) and MODIS (Moderate Resolution Imaging Spectroradiometer, b) over China between 2013 and 2017 (2017–2013)

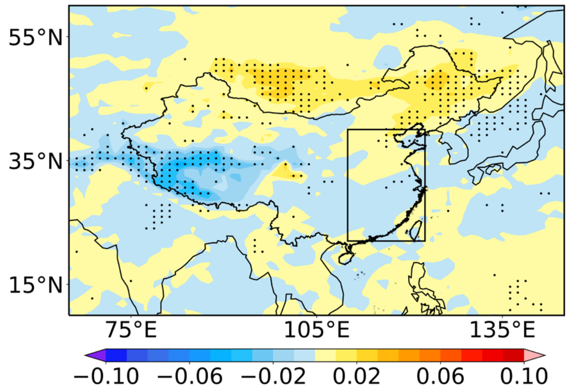

Figure S2. Spatial distributions of differences in surface albedo the changes in O_3 between 2013 and 2017, calculated as the differences between AClean and AClean_O_3 (AClean_O_3– AClean. Differences in areas that are statistically significant at 90 % from a two-tailed *t* test are stippled.

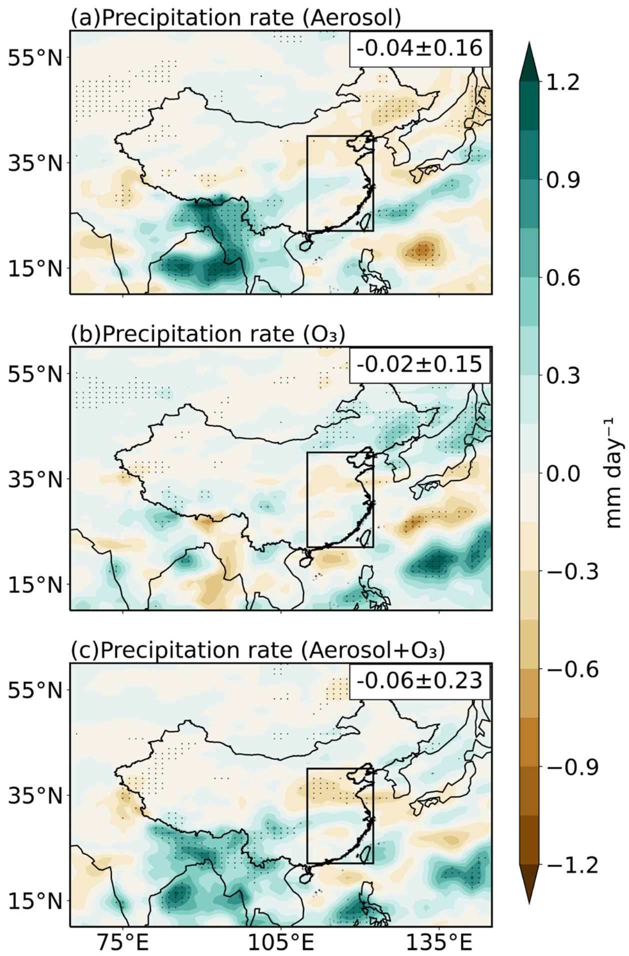

Figure S3. Spatial distributions of differences in precipitation rate (mm day^{-1}) due to the changes in (a) aerosols, (b) O_3, and (c) both aerosols and O_3 between 2013 and 2017, calculated as the differences between Base and AClean simulations (AClean–Base), between AClean and AClean_O_3 (AClean_O_3–AClean), and between Base and AClean_O_3 (AClean_O_3–Base), respectively. Differences in areas that are statistically significant at 90 % from a two-tailed *t* test are stippled.

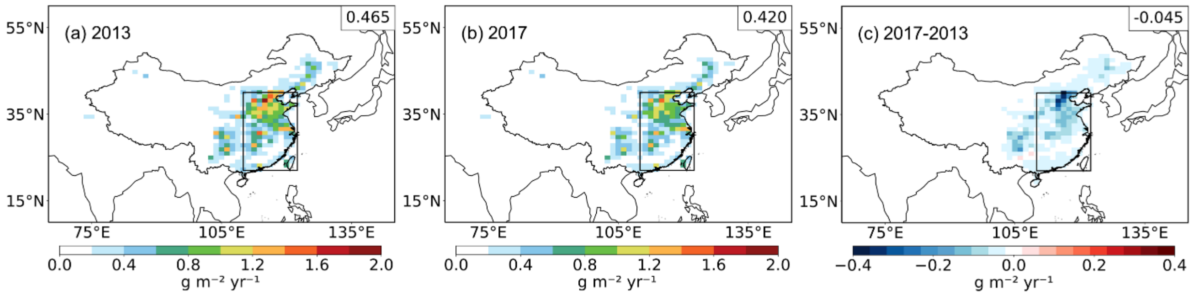

Figure S4. Spatial distributions of BC emission rate from residential sector in (a) 2013 and (b) 2017, and (c) their differences (2017–2013).

Table S1. Regional and seasonal mean column burdens of $PM_{2.5}$ (mg m^{-2}) from Base and AClean simulations, and their absolute (mg m^{-2}) and percentage (%) differences in March–April–May (MAM), June–July–August (JJA), September–October–November (SON), December–January–February (DJF), and annual mean (ANN).

Region	Simulation	MAM	JJA	SON	DJF	ANN
NCP	Base	29.16	35.18	31.17	31.93	31.86
	AClean	20.51	24.71	22.23	22.65	22.53
	AClean-Base	-8.65	-10.47	-8.94	-9.28	-9.34
	(AClean-Base)/Base	-29.59%	-29.50%	-28.45%	-29.23%	-29.18%
SCB	Base	48.57	33.99	42.16	72.40	49.28
	AClean	34.17	23.73	28.80	49.74	34.11
	AClean-Base	-14.41	-10.26	-13.36	-22.67	-15.17
	(AClean-Base)/Base	-29.58%	-29.54%	-31.25%	-30.52%	-30.28%
YRD	Base	30.19	24.65	26.34	32.46	28.41
	AClean	23.25	19.27	19.94	25.16	21.90
	AClean-Base	-6.95	-5.38	-6.41	-7.30	-6.51
	(AClean-Base)/Base	-22.97%	-21.67%	-24.19%	-22.44%	-22.81%
PRD	Base	27.04	14.87	22.02	22.70	21.66
	AClean	21.95	12.43	17.47	17.76	17.40
	AClean-Base	-5.10	-2.45	-4.54	-4.94	-4.26
	(AClean-Base)/Base	-18.76%	-16.17%	-20.64%	-21.53%	-19.55%
NEP	Base	14.31	21.91	14.44	10.49	15.29
	AClean	11.15	17.71	11.29	8.10	12.06
	AClean-Base	-3.16	-4.21	-3.15	-2.40	-3.23
	(AClean-Base)/Base	-21.50%	-18.75%	-21.69%	-22.02%	-20.65%
YGP	Base	34.55	16.62	21.33	29.24	25.43
	AClean	29.40	13.08	16.29	21.75	20.13
	AClean-Base	-5.15	-3.55	-5.04	-7.49	-5.31
	(AClean-Base)/Base	-14.46%	-21.02%	-23.53%	-24.86%	-20.38%
FWP	Base	29.62	30.94	31.61	37.52	32.42
	AClean	20.64	22.34	22.30	25.95	22.81
	AClean-Base	-8.98	-8.60	-9.32	-11.57	-9.62
	(AClean-Base)/Base	-30.32%	-27.63%	-29.36%	-30.80%	-29.58%

Table S2. Changes in $PM_{2.5}$ column burden, changes in effective radiative forcing induced by aerosol-radiation interactions (ERF_{ari}), and changes in temperature (T) averaged in eastern China due to emission reductions of aerosols and precursors between 2013 and 2017 from individual sectors, including energy transformation and extraction (ENE), industrial combustion and processes (IND), residential, commercial and other (RCO), surface transportation (TRA), solvents (SLV), waste disposal and handling (WST) and international shipping (SHP). Note that the temperature changes are calculated as the difference between AClean and Base, linearly scaled by the ratio of sectoral ERF_{ari} to the total ERF_{ari}.

	Burden (mg m^{-2})	ERF_{ari} (W m^{-2})	T (℃)
ENE	-1.506±0.051 (17.27%)	0.199±0.012 (29.01%)	0.025
IND	-4.535±0.053 (52.00%)	0.496±0.012 (72.30%)	0.063
RCO	-2.000±0.039 (22.93%)	-0.029±0.010 (-4.23%)	-0.004
SHP	-0.630±0.068 (7.22%)	0.024±0.013 (3.50%)	0.003
SLV	0.270±0.072 (-3.10%)	-0.049±0.012 (-7.14%)	-0.006
TRA	-0.418±0.048 (4.79%)	0.052±0.014 (7.58%)	0.007
WST	0.098±0.043 (-1.12%)	-0.007±0.014 (-1.02%)	-0.001

Table S3. Comparison of the results in this work with those reported in previous studies.

Reference	Model	Period	Region	ERF ($W\ m^{-2}$)		T (°C)	
				Aerosol	O_3	Aerosol	O_3
This paper	CESM2 (CAM6)	2013–2017	Eastern China (110–122.5°E, 22–40°N)	1.18	0.81	0.09	0.07
Zheng et al. (2020)	CESM1 (CAM5, POP2)	2006–2017	East Asia (70–155°E, 0–55°N)	0.48	/	0.12	/
Dang and Liao (2019)	GEOS-Chem	2012–2017	Eastern China (105–122.5°E, 20–45°N)	1.18*	0.08*	/	/

*Note that the radiative forcing in Dang and Liao (2019) is the direct radiative forcing without semi-direct effects, while the other studies show total ERF values.

GEOS-Chem (http://www.geos-chem.org) is a global 3-D model of atmospheric chemistry driven by meteorological input from the Goddard Earth Observing System (GEOS). The detailed information about chemistry, aerosol process, transport, deposition, and radiation in GEOS-Chem is available at https://geos-chem.seas.harvard.edu/.

CESM2/CESM1 (https://www.cesm.ucar.edu) is the coupled climate/Earth system models developed by the National Center for Atmospheric Research (NCAR). Its atmosphere model is the Community Atmosphere Model Version 6/5 (CAM6/CAM5). The detail information about chemical and physical schemes and the changes between CAM5 and CAM6 are available in Danabasoglu et al. (2020).

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