Mapping between CESM/CAM5 and CMAQ aerosol species

The mapping table between CESM/CAM5 and CMAQ aerosol species is shown in Table S1. The CESM/CAM5 uses the 7-mode prognostic Modal Aerosol Model (MAM7) (Liu et al., 2012) with volatility-basis-set (VBS) (Glotfelty et al., 2016b), whereas CMAQ uses the 3-mode AERO6 aerosol module. The MAM7 in CESM/CAM5 includes Aitken (2), accumulation (1), primary carbon (3), fine dust (5), fine sea salt (4), coarse dust (7) and coarse sea salt (6) modes. The AERO6 in CMAQ includes Aitken (I), accumulation (J) and coarse (K) modes, which is similar to MAM3 (Liu et al., 2012). Similar to the mapping of aerosol modes between MAM7 and MAM3 in Liu et al. (2012), the Aitken mode in MAM7 is mapping to the Aitken mode (I) in AERO6; the accumulation, primary carbon, fine dust and fine sea salt modes in MAM7 are mapping to the accumulation mode (J) in AERO6; the coarse dust and coarse sea salt modes in MAM7 are mapping to the coarse mode (K) in AERO6. For example, sulfate in accumulation mode (so4_a1), fine sea salt mode (so4_a4) and fine dust mode (so4_a5) in MAM7 are mapping to sulfate in accumulation mode (ASO4J) in AERO6.

Secondary organic aerosol (SOA) species in CESM/CAM5 were divided according to different volatility levels. However, the CMAQ model includes specific SOA semi-volatile and nonvolatile species. The anthropogenic and biogenic SOA species in CESM/CAM5 were first lumped into total semi-volatile SOA and total nonvolatile SOA. The ratios among the SOA species derived from the default BCs/ICs were then used to allocate each SOA species in CMAQ based on the combined SOA, as suggested by Carlton et al. (2010).

Table S1. Mapping table between CESM/CAM5 and CMAQ aerosol species.

CMAQ	CESM/CAM5
J - Accumulation	1 - Accumulation
I - Aitken	2 - Aitken
J - Accumulation	3 - Primary Carbon
J - Accumulation	4 - Fine Sea Salt
J - Accumulation	5 - Fine Dust
K - Coarse	6 - Coarse Sea Salt
K - Coarse	7 - Coarse Dust
ASO4J	so4_a1+so4_a4+so4_a5
ASO4I	so4_a2
ASO4K	so4_a6+so4_a7
ANO3J	no3_a1+no3_a4+no3_a5
ANO3I	no3_a2
ANO3K	no3_a6+no3_a7
ANH4J	nh4_a1+nh4_a4+nh4_a5
ANH4I	nh4_a2
ANH4K	nh4_a6+nh4_a7
AECJ+AECI	bc_a1+bc_a3
APOCJ+APNCOMJ+APOCI+APNCOMI	poa1_a1+poa2_a1+poa3_a1+poa4_a1+poa5_a1+poa6_a1+poa7_a1+poa1_a3+poa2_a3+poa3_a3+poa4_a3+poa5_a3+poa6_a3+poa7_a3
AALKJ+AXYL1J+AXYL2J+ATOL1J+ATOL2J+ABNZ1J+ABNZ2J	asoa2_a1+asoa2_a2+asoa3_a1+asoa3_a2+asoa4_a1+asoa4_a2
AXYL3J+ATOL3J+ABNZ3J+AOLGAJ	asoa1_a1+asoa1_a2
ATRP1J+ATRP2J+AISO1J+AISO2J+ASQTJ	bsoa2_a1+bsoa2_a2+bsoa3_a1+bsoa3_a2+bsoa4_a1+bsoa4_a2
AISO3J+AOLGBJ	bsoa1_a1+bsoa1_a2
AORGCJ	soa_a1+soa_a2
ANAJ	na_a1+na_a4+na_a2
ASEACAT	na_a6
ACLJ	cl_a1+cl_a4+cl_a5
ACLI	cl_a2
ACLK	cl_a6+cl_a7
AOTHRJ+AFEJ+AALJ+ASIJ+ATIJ+ACAJ+AMGJ+AKJ+AMNJ	dst_a5
ACORS+ASOIL	dst_a7

Evaluation of dust simulation in CESM-NCSU

The 5-year average (2006-2010) PM_{10} concentrations from CESM-NCSU were evaluated by comparison with observed data in 2013 to assess the performance of the dust emission scheme used in CESM-NCSU. CESM-NCSU tends to overpredict dust concentrations over East Asia in April, and a scale factor of 1/3 was thus applied to adjust dust concentrations from CESM-NCSU, which helped reduce the high bias in dust simulation (see Fig. S1).

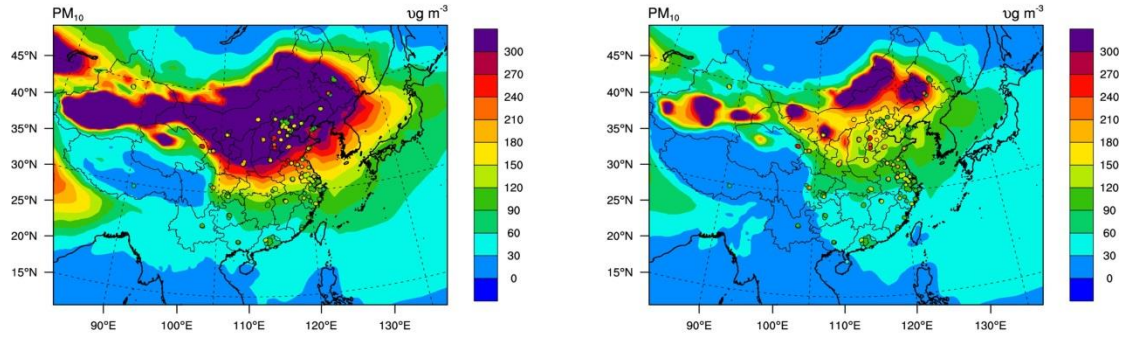

Fig. S1. 5-year average (2006-2010) simulated PM_{10} concentrations in April from (a) original CESM-NCSU and (b) dust-revised CESM-NCSU (CESM_0.33Dust) overlaid with observations in 2013.

Table S2. Mapping table between RCP and MIX sectors.

RCP	MIX
energy	power
industry	industry
domestic combustion	residential
transport	transportation
agriculture	agriculture
solvent use	industry/residential
waste treatment	residential
open burning of agricultural waste	residential
biomass burning	-
shipping	-
aviation sectors	-

Table S3. Model performance statistics for the air quality application: meteorological variables (2013, NCEP_BASE_Imp).

Variable	Network	January				April				July			
		R	MB	NMB (%)	NME (%)	R	MB	NMB (%)	NME (%)	R	MB	NMB (%)	NME (%)
T2 (℃)	NCDC	1.0	0.2	-105.4	-1230	0.9	-1.2	-10.1	21.4	0.8	-1.8	-7.3	11.4
RH2 (%)	NCDC	0.6	4.0	5.9	20.1	0.7	3.4	5.4	22.0	0.7	2.8	3.7	15.1
WS10 (m s^{-1})	NCDC	0.6	0.7	26.3	62.6	0.6	0.2	7.0	50.0	0.5	0.2	6.3	54.6
WDR10 (degree)	NCDC	0.4	7.4	3.6	38.6	0.4	4.4	2.2	33.1	0.3	5.9	3.2	33.1
Precip (mm day^{-1})	NCDC	0.1	0.3	35.4	185.3	0.5	0.2	7.7	119.3	0.4	0.4	7.7	122.2
Precip (mm day^{-1})	GPCP	0.7	-0.2	-16.9	61.3	0.7	-0.4	-21.3	48.3	0.7	-0.4	-6.8	52.5
SWDOWN (W m^{-2})	CERES	0.9	13.5	11.1	14.9	0.8	33.1	14.4	15.0	0.7	42.6	18.9	20.8
LWDOWN (W m^{-2})	CERES	1.0	-9.8	-3.6	4.6	1.0	-14.3	-4.4	4.5	1.0	-11.6	-3.0	3.6
GSW (W m^{-2})	CERES	0.9	2.3	2.4	15.4	0.8	18.2	9.4	12.5	0.7	30.7	15.6	18.2
OLR (W m^{-2})	CERES	1.0	3.0	1.3	3.1	0.9	5.9	2.4	4.3	0.7	5.3	2.3	7.2
SWCF (W m^{-2})	CERES	0.8	4.5	-16.1	-41.1	0.8	20.2	-38.1	-40.4	0.7	22.1	-26.8	-35.5
LWCF (W m^{-2})	CERES	0.6	-6.8	-41.6	46.9	0.6	-11.5	-42.8	46.2	0.6	-11.5	-25.5	39.6
CF (%)	MODIS	0.6	-23.5	-34.2	38.6	0.5	-19.2	-31.4	36.5	0.5	-17.4	-23.8	28.0

[1] R: correlation coefficient; MB: mean bias; NMB: normalized mean biases; NME: normalized mean error.

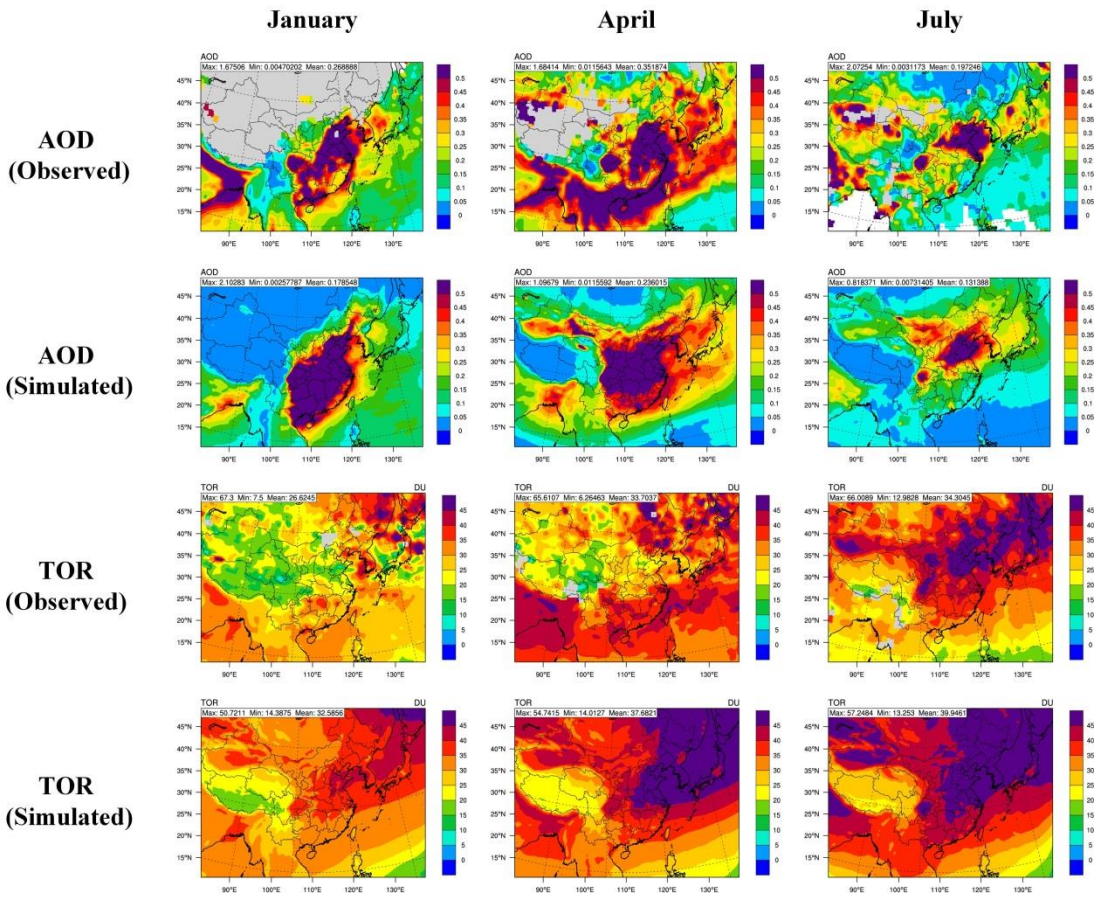

Fig. S2. Spatial distribution of satellite-derived and simulated AOD and TOR during January, April and July 2013 under the short-term air quality application.

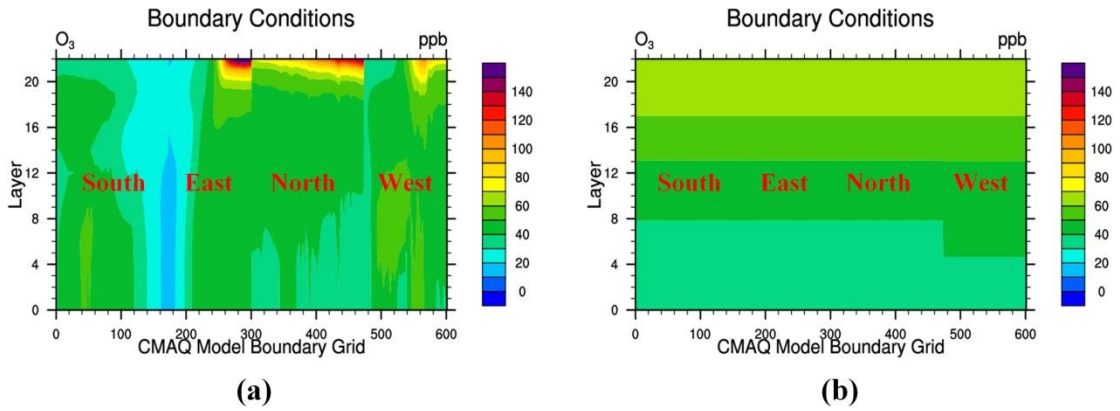

Fig. S3. O_3 boundary conditions (BCs) in January derived from (a) CESM and (b) fixed boundary conditions (BCs).

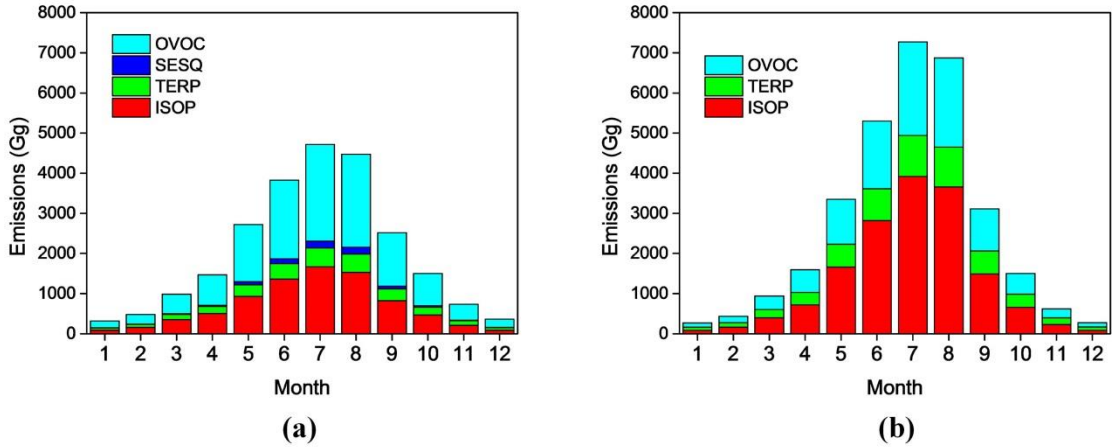

Fig. S4. Biogenic VOC emissions over China in 2013 estimated by (a) BEIS and (b) MEGAN.