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Supplement of

IAP-AACM v1.0: a global to regional evaluation of the atmospheric chemistry model in CAS-ESM

Ying Wei et al.

Correspondence to: Zifa Wang (zifawang@mail.iap.ac.cn)

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Table S1. The list of observation sites information

Number	Site name (ID)	Longitude	Latitude
WDCGG Dataset			
1	asc107s00.noa	-14.42	-7.92
2	ask123n00.noa	5.63	23.27
3	azr638n00.noa	-27.37	38.77
4	bhd541s00.noa	174.87	-41.4
5	bkt500s00.bmg	100.32	-0.2
6	bmw432n00.noa	-64.87	32.27
7	brw471n00.noa	-156.6	71.32
8	cba455n00.noa	-162.72	55.2
9	cfa519s00.csi	147.05	-19.3
10	cgo540s00.csi	144.68	-40.7
11	cmn644n00.isa	10.7	44.18
12	cpt134s00.saw	18.48	-34.4
13	crz146s00.noa	51.85	-46.5
14	cvo116n00.uyr	-24.87	16.85
15	cya766s00.csi	110.53	-66.3
16	egb444n01.ec.	-79.78	44.23
17	eic327s00.noa	-109.45	-27.1
18	etl454n00.ec.	-104.98	54.35
19	glh636n00.uml	14.22	36.07
20	gmi513n00.noa	144.78	13.43
21	hba775s00.noa	-26.5	-75.6
22	hpb647n00.noa	11.02	47.8
23	hun646n00.noa	16.65	46.95
24	ice663n00.noa	-20.28	63.4
25	izo128n00.aem	-16.5	28.3
26	key425n00.noa	-80.2	25.67
27	kos649n00.chm	15.08	49.58
28	kum519n00.noa	-154.82	19.52
29	kvv646n00.ars	14.53	46.3
30	lef445n00.noa	-90.27	45.92
31	lln223n00.noa	120.87	23.47
32	lmp635n00.noa	12.63	35.52
33	maa767s00.csi	62.87	-67.6
34	mex419n00.noa	-97.17	19.98
35	mhd653n00.noa	-9.9	53.33
36	mid528n00.noa	-177.37	28.2
37	mlo519n00.csi	-155.58	19.54
38	mnm224n00.jma	153.98	24.28
39	mqa554s00.csi	158.97	-54.5
40	nat306s00.noa	-35.2	-6

Number	Site name (ID)	Longitude	Latitude
41	nmb123s00.noa	15.02	-23.6
42	nwr440n01.noa	-105.59	40.05
43	oxk650n00.noa	11.8	50.03
44	pal667n00.noa	24.12	67.97
45	poc900n00.noa	-155	0
46	poc905n00.noa	-151	5
47	poc905s00.noa	-159	-5
48	poc910n00.noa	-149	10
49	poc910s00.noa	-161	-10
50	poc915n00.noa	-145	15
51	poc915s00.noa	-171	-15
52	poc920n00.noa	-141	20
53	poc920s00.noa	-174	-20
54	poc925n00.noa	-139	25
55	poc925s00.noa	-171	-25
56	poc930n00.noa	-135	30
57	poc930s00.noa	-176	-30
58	psa764s00.noa	-64	-64.9
59	rig646n00.emp	8.45	46.07
60	rpb413n00.noa	-59.43	13.17
61	ryo239n00.jma	141.82	39.03
62	sey104s00.noa	55.17	-4.67
63	sgp436n00.noa	-97.5	36.78
64	smo514s00.noa	-170.57	-14.2
65	spo789s00.csi	-24.8	-90
66	sum672n00.noa	-38.48	72.58
67	syo769s00.noa	39.58	-69
68	tap236n00.noa	126.12	36.72
69	thd441n00.noa	-124.15	41.05
70	ush354s00.noa	-68.31	-54.9
71	uta439n00.noa	-113.72	39.88
72	uum244n00.noa	111.08	44.45
73	wis631n00.noa	34.87	31.12
74	wlg236n00.cma	100.9	36.28
75	yon224n00.jma	123.02	24.47
76	zep678n00.noa	11.88	78.9
77	dig654n00.ioe	22.07	54.15
78	glh636n00.uml	14.22	36.07
79	irb645n00.ars	14.87	45.57
80	kos649n00.chm	15.08	49.58
81	kps646n00.hms	19.55	46.97
82	pay646n00.emp	6.95	46.82
83	rcv656n00.lhm	21.17	56.16

Number	Site name (ID)	Longitude	Latitude
84	rig646n00.emp	8.45	46.07
85	amy236n00.kma	126.32	36.53
86	arh777s00.noa	166.67	-77.8
87	ask123n00.onm	5.63	23.27
88	bhd541s00.niw	174.87	-41.4
89	bmw432n00.noa	-64.87	32.27
90	brw471n00.noa	-156.6	71.32
91	cpt134s00.saw	18.48	-34.4
92	cvo116n00.uyr	-24.87	16.85
93	glh636n00.uml	14.22	36.07
94	irb645n00.ars	14.87	45.57
95	jfj646n00.emp	7.99	46.55
96	kos649n00.chm	15.08	49.58
97	kps646n00.hms	19.55	46.97
98	kvk646n00.ars	15.1	46.12
99	kvv646n00.ars	14.53	46.3
100	lau545s00.noa	169.67	-45
101	mhd653n00.nui	-9.9	53.33
102	mlo519n00.noa	-155.58	19.54
103	mnm224n00.jma	153.98	24.28
104	nmy770s00.awi	-8.25	-70.7
105	nwr440n00.noa	-105.54	40.04
106	pay646n00.emp	6.95	46.82
107	prs645n00.rse	7.7	45.93
108	rig646n00.emp	8.45	46.07
109	rpb413n00.noa	-59.43	13.17
110	ryo239n00.jma	141.82	39.03
111	smo514s00.noa	-170.57	-14.2
112	spo789s00.noa	-24.8	-90
113	sum672n00.noa	-38.48	72.58
114	syo769s00.jma	39.58	-69
115	thd441n00.noa	-124.15	41.05
116	tkb236n10.jma	140.13	36.05
117	tll330s00.dmc	-70.8	-30.2
118	ush354s00.smn	-68.31	-54.9
119	vdl664n00.ivl	19.77	64.25
120	yon224n00.jma	123.02	24.47
121	zrn646n00.ars	15	46.43
122	zsn657n00.lhm	25.54	57.08
123	dig654n00.ioe	22.07	54.15
124	glh636n00.uml	14.22	36.07
125	irb645n00.ars	14.87	45.57
126	jfj646n00.emp	7.99	46.55

Number	Site name (ID)	Longitude	Latitude
127	kos649n00.chm	15.08	49.58
128	kps646n00.hms	19.55	46.97
129	pay646n00.emp	6.95	46.82
130	rcv656n00.lhm	21.17	56.16
131	rig646n00.emp	8.45	46.07

EANET

num	staid	lon	lat
1	PhnomPenh	104.83	11.55
2	Jakarta	106.83	-6.18
3	Serpong	106.57	6.25
4	Bandung	107.58	6.9
5	Rishiri	141.2	45.12
6	Ochishi	145.5	43.15
7	Tappi	140.35	41.25
8	Sado-seki	138.4	38.23
9	Ijira	136.68	35.57
10	Oki	133.18	36.28
11	Banryu	131.8	34.68
12	Hedo	128.25	26.87
13	Ogasawara	142.22	27.08
14	PetalingJaya	101.65	3.1
15	DanumValley	117.85	4.98
16	Yangon	96.12	16.5
17	Kanghwa	126.28	37.7
18	Cheju	126.17	33.3
19	Imsil	127.18	35.6
20	Listvyanka	104.9	51.85
21	Irkutsk	104.25	52.23
22	Primorskaya	132.12	43.7
23	Bangkok	100.53	13.77
24	Khanchanaburi	98.58	14.77
25	ChiangMai	98.93	18.77
26	NakhonRatchasima	101.88	14.45
27	Hanoi	105.85	21.02
28	HoaBinh	105.33	20.82
29	Tokyo	139.75	35.68
30	NakhonRatchasima	101.88	14.45
31	Mt.Sto.Tomas 1	120.6	6.42
32	Hongwen	118.13	24.47
33	XiangZhou	113.57	22.27
34	Kototabang	100.32	0.2
35	Ulaanbaatar	106.82	47.9
36	Samutprakarn	100.57	13.73

Number	Site name (ID)	Longitude	Latitude
37	Mondy	101	51.67
38	Happo	137.8	36.7
39	MtStoTomas	120.6	16.42
40	Khanchanaburi	98.58	14.77
EMEP			
1	Waldhof	10.76	52.8
2	Schauinsland	7.91	47.91
3	Neuglobsow	13.03	53.17
4	Lahemaa	25.9	59.5
5	Uto	21.38	59.78
6	Virolahti	27.69	60.53
7	Pallas	24.24	68
8	K-pusztá	19.58	46.97
9	Oak	-6.92	52.87
10	Malin	-7.34	55.38
11	Carnsore	-6.36	52.18
12	Rucava	21.17	56.16
13	Birkenes	8.25	58.39
14	Karvatn	8.88	62.78
15	Zeppelin	11.89	78.91
16	Hurdal	11.08	60.37
17	Jarczew	21.97	51.81
18	Sniezka	15.74	50.74
19	Leba	17.53	54.75
20	Diabla	22.07	54.15
21	Danki	37.8	54.9
22	Iskrba	14.87	45.57
23	Starina	22.27	49.05
24	Melpitz_1	12.93	51.53
25	Ispra	8.63	45.8
26	Cabauw	4.92	51.97
27	Illmitz	16.77	47.77
28	Vorhegg	12.97	46.68
29	Zoebelboden	14.44	47.84
30	Payerne	6.94	46.81
31	Tanikon	8.9	47.48
32	Chaumont	6.98	47.05
33	Rigi	8.46	47.07
34	Churanov	13.6	49.07
35	Westerland	8.31	54.93
36	Zingst	12.73	54.43
37	Harwell	-1.32	51.57
38	Auchencorth	-3.24	55.79

Number	Site name (ID)	Longitude	Latitude
39	Kamenicki	21.95	43.4
40	Schmucke	10.77	50.65
41	San	-4.35	39.55
42	Cabo	3.32	42.32
43	Zarra	-1.1	39.09
44	Penausende	-5.87	41.28
45	Els	0.72	41.4
46	Rao	11.91	57.39

IMPROVE

1	ACAD1	-68.261	44.377
2	BLMO1	-96.191	43.716
3	BRMA1	-70.729	44.107
4	CEBL1	-99.763	38.77
5	DENA1	-148.968	63.723
6	EVER1	-80.681	25.391
7	GAAR1	-151.517	66.903
8	GRR11	-91.405	43.937
9	HEGL1	-92.922	36.614
10	KALM1	-124.059	42.552
11	LOST1	-102.402	48.642
12	MING1	-90.143	36.972
13	NEBR1	-100.339	41.889
14	OWVL1	-118.331	37.361
15	PMRF1	-72.869	44.528
16	RAFA1	-120.007	34.734
17	SAGO1	-116.913	34.194
18	SENE1	-85.95	46.289
19	SIME1	-160.506	55.325
20	TALL1	-96.56	38.434
21	TRIN1	-122.805	40.786
22	WHIT1	-105.535	33.469
23	ZICA1	-113.151	37.198

EPA

1	10730023	-86.82	33.55
2	40128000	-113.56	34.24
3	60530002	-121.64	36.7
4	60831008	-120.05	34.49
5	90090027	-72.9	41.3
6	120573002	-82.54	27.89
7	120860033	-80.16	25.73
8	170310022	-87.64	41.88
9	171190024	-90.16	38.61
10	180570007	-85.77	39.29

11	191770006	-92.01	40.7
12	201330003	-95.48	37.68
13	360610079	-73.9	40.82
14	380171004	-96.86	46.93
15	380250003	-102.53	47.31
16	410510080	-122.6	45.5
17	420010001	-77.31	39.92
18	420031008	-79.73	40.61
19	450450015	-82.41	34.84
20	460990006	-96.7	43.55
21	461030020	-103.27	44.09
22	461270001	-96.71	42.75
23	550870009	-88.81	45.56
24	560030003	-108.39	44.84
25	20200018	-149.82	61.21
26	21100004	-134.57	58.39
27	21221006	-151.69	59.46
28	21700008	-149.03	61.53
29	40131003	-111.87	33.41
30	40133010	-112.12	33.46
31	40278011	-114.61	32.69
32	51190007	-92.28	34.76
33	60070008	-121.84	39.76
34	60090001	-120.68	38.2
35	60510005	-119.12	37.96
36	60970001	-123.02	38.8
37	60990005	-120.99	37.64
38	120570083	-82.38	27.86
39	150030010	-158.09	21.32
40	300290009	-114.34	48.4
41	300710010	-107.86	48.32
42	410390059	-123.14	44.07
43	420030003	-79.77	40.45
44	530330080	-122.31	47.57
45	530630021	-117.36	47.67
46	560350100	-110.06	42.79
47	560370007	-109.22	41.59
48	560370300	-109.79	41.75
49	560370866	-109.79	41.63
50	560370867	-108.67	41.75
51	10030010	-87.88	30.5
52	21220008	-151.07	60.49
53	40011235	-109.44	35.88
54	50010011	-91.56	34.52

55	60010007	-121.78	37.69
56	60410001	-122.52	37.97
57	60670006	-121.37	38.61
58	60710306	-117.33	34.51
59	60730003	-116.94	32.79
60	60731006	-116.77	32.84
61	60750005	-122.4	37.77
62	60771002	-121.27	37.95
63	61111004	-119.23	34.45
64	100010002	-75.56	38.99
65	131210039	-84.44	33.8
66	131350002	-84.07	33.96
67	150011006	-155.11	19.72
68	160410001	-111.81	42.01
69	330115001	-71.88	42.86
70	380070002	-103.38	46.89
71	471570047	-90.02	35.17
72	550090005	-87.99	44.51
73	560290001	-109.07	44.53
74	20900034	-147.73	64.85
75	40070009	-110.86	33.4
76	60010011	-122.28	37.81
77	80013001	-104.95	39.84
78	90010012	-73.16	41.2
79	120110010	-80.17	26.13
80	120170006	-82.64	28.96
81	160050004	-112.52	42.92
82	170191001	-88.37	40.05
83	220150008	-93.75	32.54
84	230090103	-68.26	44.38
85	230112005	-69.79	44.23
86	230310009	-70.77	43.11
87	240053001	-76.47	39.31
88	271095008	-92.45	44
89	300490004	-111.99	46.85
90	390350038	-81.68	41.48
91	390810017	-80.62	40.37
92	390850003	-81.42	41.67
93	401430235	-96	36.13

CAWNET

1	Chengdu	104.3	30.6
2	Dalian	121.6	38.9
3	Dunhuang	94.67	40.1
4	Gaolanshan	105.8	36

5	Gucheng	115.8	39.1
6	Jinsha	114.2	29.6
7	LinAn	119.7	30.3
8	Longfengshan	127.5	44.7
9	Shangdianzi	117.1	40.7
10	Taiyangshan	111.7	29.2
11	Xian	109	34.5
12	Zhenbeitai	109.2	38.5
13	Zhengzhou	113.7	34.8

CNEMC

1	11000041	116.17	40.29
2	110000244	116.43	39.95
3	110000245	116.43	39.87
4	110000246	116.4	39.98
5	110000247	116.47	39.97
6	110000249	116.22	39.93
7	110000250	116.36	39.94
8	110000251	116.32	39.99
9	110000252	116.37	39.87
10	110000253	116.72	40.14
11	110000254	116.64	40.39
12	110000255	116.23	40.2
13	440100051	113.24	23.14
14	440100057	113.26	23.13
15	440100063	113.28	23.16
16	440100064	113.26	23.1
17	440100073	113.32	23.14
18	440100088	113.35	23.09
19	440100089	113.43	23.1
20	440100090	113.35	22.95
21	440100091	113.21	23.39
22	440100092	113.57	23.28
23	442000051	113.38	22.52
24	442000052	113.39	22.55
25	442000053	113.41	22.51
26	131000402	116.68	39.52
27	131000403	116.77	39.57
28	131000407	116.71	39.56
29	131000408	116.75	39.53
30	410100051	113.64	34.75
31	410100052	113.6	34.75
32	410100053	113.68	34.75
33	410100054	113.64	34.77
34	410100062	113.68	34.8

35	410100063	113.56	34.8
36	410100064	113.73	34.72
37	410100065	113.73	34.72
38	420100051	114.28	30.62
39	420100052	114.15	30.48
40	420100053	114.25	30.55
41	420100054	114.3	30.55
42	420100055	114.37	30.57
43	420100056	114.43	30.61
44	420100057	114.3	30.59
45	420100075	114.39	30.48
46	420100076	114.21	30.64
47	320600073	120.86	32
48	320600074	120.87	32.02
49	320600077	120.94	31.93
50	320600078	120.81	32.04
51	320900401	120.12	33.4
52	320900402	120.16	33.39
53	320900403	120.13	33.37
54	320900406	120.22	33.39
55	310000051	121.4	31.24
56	310000052	121.54	31.27
57	310000053	121.48	31.2
58	310000055	121.47	31.3
59	310000056	121.43	31.23
60	310000057	121.41	31.17
61	310000058	121.53	31.23
62	310000059	121.58	31.21
63	310000251	121.7	31.19
64	510100051	104.05	30.66
65	510100052	104.03	30.65
66	510100054	104.12	30.64
67	510100064	104.07	30.68
68	510100073	104.08	30.57
69	510100074	104.18	30.69
70	510100075	103.97	30.71
71	120000051	117.15	39.1
72	120000062	117.14	39.17
73	120000072	117.18	39.12
74	120000081	117.19	39.17
75	120000095	117.24	39.11
76	120000100	117.27	39.13
77	120000104	117.2	39.09
78	120000137	117.46	38.84

79	120000143	117.71	39.03
80	120000168	117.31	39.09
81	120000186	117.18	39.23
82	120000301	117.4	39.12
83	120000302	117.76	39.16
84	650100051	87.6	43.77
85	650100055	87.58	43.83
86	650100056	87.55	43.87
87	650100071	87.64	43.83
88	650100072	87.42	43.87
89	650100091	87.64	43.96
Aerosol sites in China			
1	Beijing	116.371	39.974
2	Xinzhou	112.12	38.07
3	Nanjing	118.749	32.057
4	Wuhan	114.284	30.62

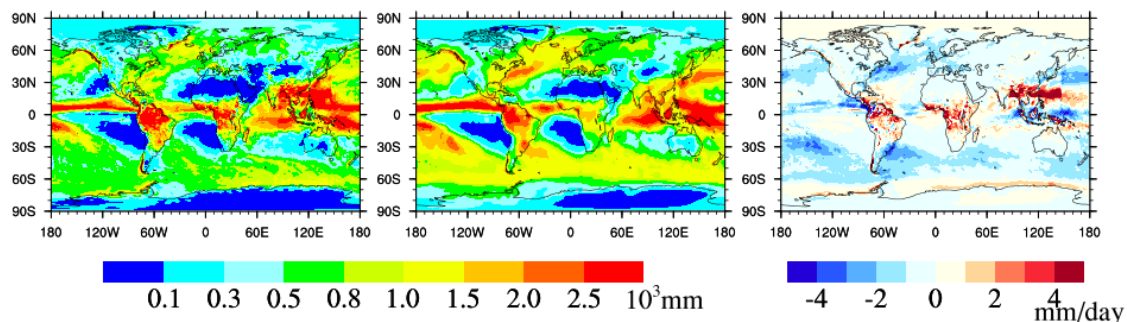
Table S2. the budget of O₃ and CO compared with the other models.

Species	Process	IAP-AACM
	Anthrop.	546.4
	Emission	
	(Tg yr ⁻¹)	
	Bio. burning	336.2
	Biogenic	92.7
	Total 994	
	Others	18.3
CO	Top condition inflow (Tg yr ⁻¹)	28
	Chem pro (Tg yr ⁻¹)	1270
	Chem lss (Tg yr ⁻¹)	2292
	Dry dep (Tg yr ⁻¹)	0
	Burden (Tg)	327
	Lifetime (days)	52
	Top condition inflow (Tg yr ⁻¹)	398
	Chemical production (Tg yr ⁻¹)	4526
	Chemical loss (Tg yr ⁻¹)	3875
O ₃	Dry dep. (Tg yr ⁻¹)	1049
	Burden (Tg)	370
	Lifetime (days)	27.4

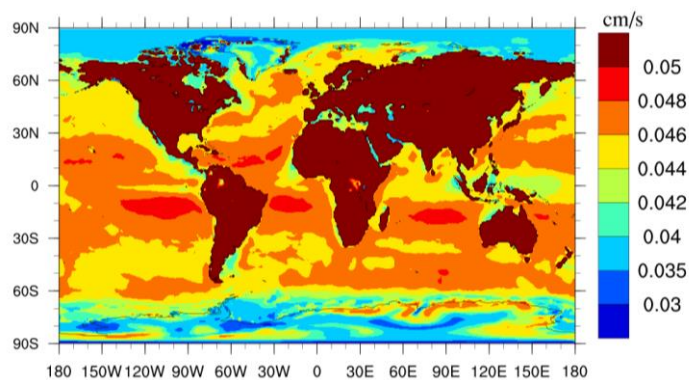
5 Table S3. NMB of global domain in different regions. The NMB is calculated with annual average concentration. ASO₄, ANO₃ and ANH₄ represents sulfate, nitrate and ammonium, respectively.

	CO	O ₃	NO ₂	SO ₂	ASO ₄	ANO ₃	ANH ₄	BC	OC	PM _{2.5}
Africa	-0.47	-0.09								
Antarctica	-0.50	-0.34								
ArcticO	-0.45									
Asia	-0.34	0.94	-0.14	0.05	0.36	-0.61	0.85	-0.4	-0.67	-0.36
AtlanticO	-0.54	0.16								
Europe	-0.39	0.10	0.16	3.79	1.1	0.74	1.49	-0.62	-0.55	-0.35
IndianO	-0.53									
NAmerica	-0.23	-0.18	-0.14	3.51	1.94	0.50	-0.46	0.64	-0.12	1.16
Oceania	-0.45	-0.04								
PacificO	-0.59	0.14								
SAmerica	-0.47	-0.12								

Figures



10 Fig. S1. Annual mean precipitation of WRF compared with GPCP data. The left column is WRF simulation (unit: mm), the middle column is GPCP reanalysis data (unit: mm), the right column is the difference between simulation and reanalysis (WRF-GPCP) (unit: mm day^{-1}).



15

Fig. S2. Annual mean dry deposition velocity of ozone in IAP-AACM. The unit is cm s^{-1} .

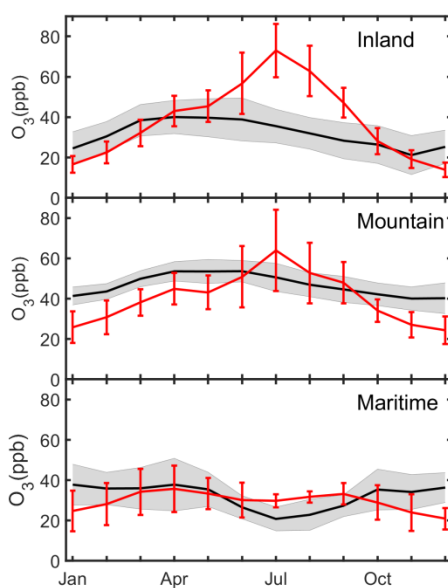


Fig. S3. Mean seasonal variation of O_3 (ppb) over inland, mountain and maritime area

in Northern Hemisphere compared with site records. Black lines and red lines
 20 represent the average of observations and simulations respectively. Gray shaded areas
 and red vertical bars show 1 standard deviation over the sites for observations and for
 model results respectively.

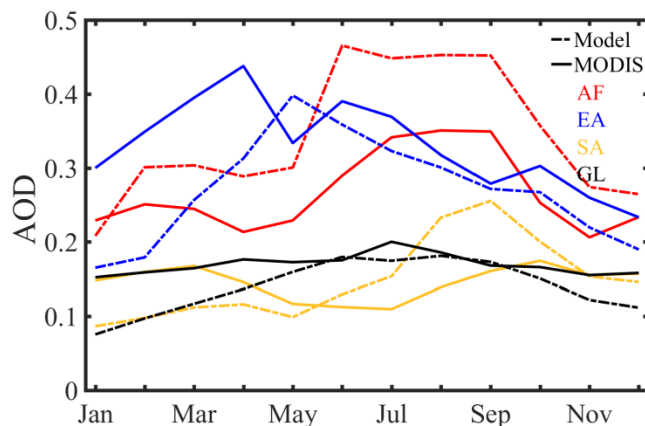


Fig. S4. Gridded mean value of monthly averaged AOD for 2014, AF, EA, SA and
 25 GL represents Africa, East Asia, South America and global. Dash line and solid line
 represents model results and observation derived from MODIS, respectively.

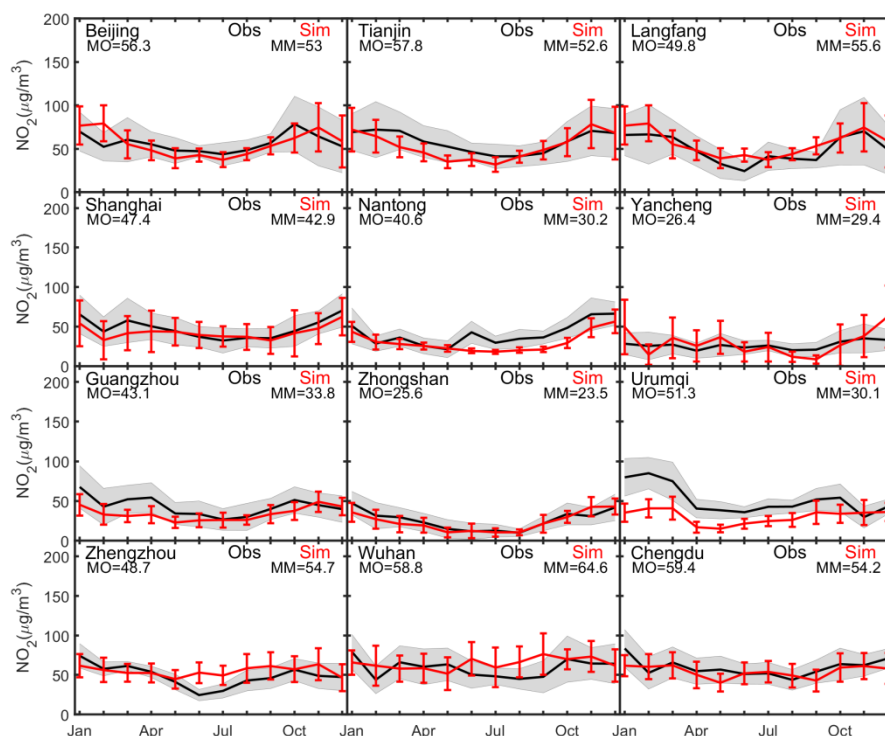
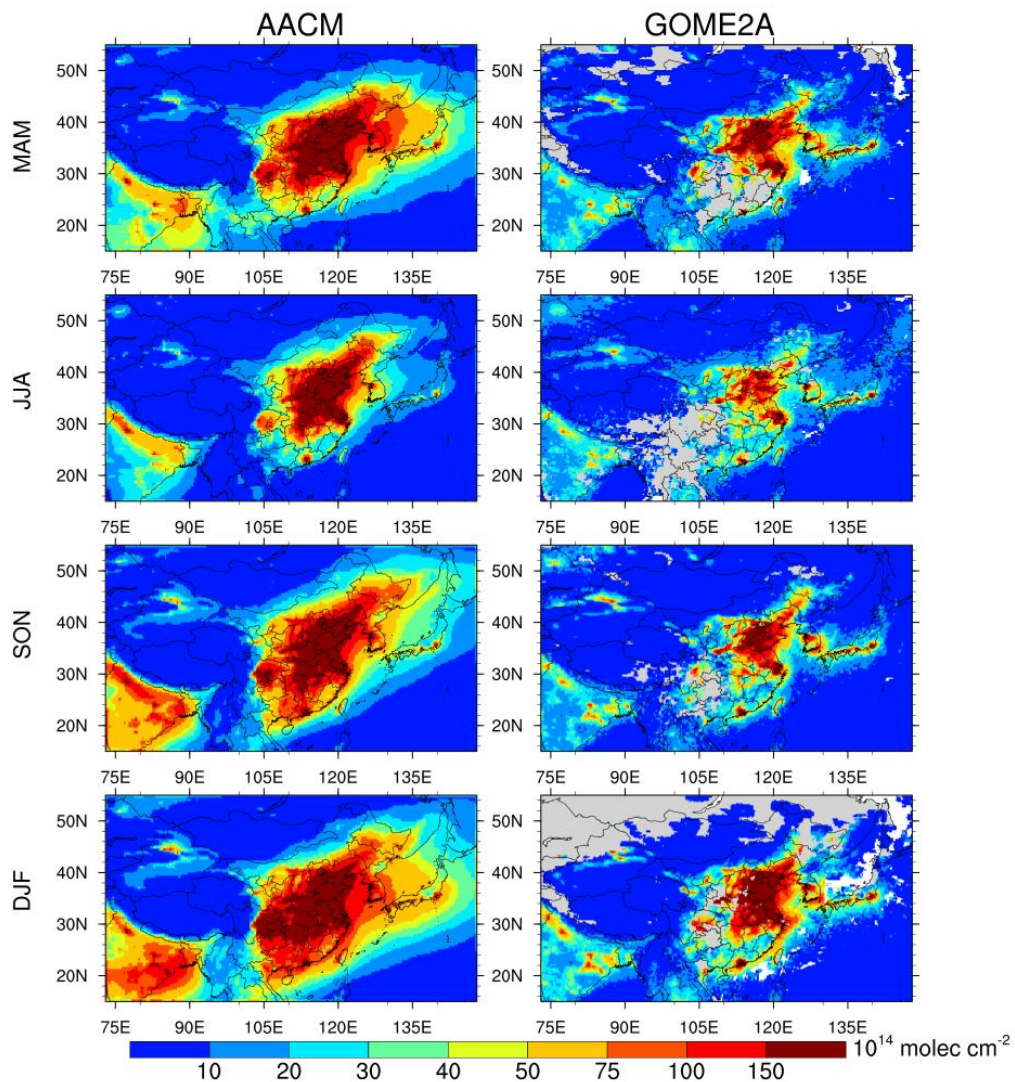


Fig. S5. Seasonal cycle of NO_2 ($\mu\text{g m}^{-3}$) simulated without heterogeneous chemical
 30 process over China. The black line and red line represent monthly mean concentration
 of city-averaged observation and simulation respectively. Gray shaded areas and red

vertical bars show 1 standard deviation over the sites for observations and for model results, respectively. MO and MM stand for annual mean concentration of observation and simulation respectively.



35 Fig. S6. Seasonal mean column concentration (10^{14} molecule cm^{-2}) of NO_2 in IAP-AACM and GOME-2A over China.