

Supplement of

Impacts of land cover changes on the contribution of biogenic emissions to ozone and secondary organic aerosol in China

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15 **Table S1. WRF model physics schemes used in this study.**

Physical mechanism	Scheme	Reference
Microphysics	Thompson scheme	(Thompson et al., 2008)
Long-wave radiation	RRTM scheme	(Iacono et al., 2008)
Short-wave radiation	Goddard short wave	(Chou and Suarez, 1999)
Land Surface	Thermal diffusion scheme	(Dudhia, 1996)
PBL Scheme	YSU scheme	(Hong, 2010;Hong et al., 2006)
Cumulus parameter	Grell-Freitas ensemble scheme	(Grell and Freitas, 2014)

Table S2. The sources of datasets.

Datasets	Source
MODIS MCD12Q1	Available at https://search.earthdata.nasa.gov/ , last access: 10 April 2022
C3S LC	Available at https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-land-cover?tab=form , last access: 21 March 2022
CGLS LC	Available at https://land.copernicus.eu/global/products/lc , last access: 15 April 2022
MODIS MOD15	Available at https://search.earthdata.nasa.gov/ , last access: 10 April 2022
GLASS	Available at http://www.glass.umd.edu/LAI/MODIS/ , last access: 11 April 2022
CGLS	Available at https://land.copernicus.eu/global/products/lai , last access: 10 April 2022

Table S3. Indices used to evaluate model performance.

Index	Definition*	Remarks
Mean bias (MB)	$\frac{1}{N} \sum_{i=1}^N (M_i - O_i)$	
Root mean square error (RMSE)	$\sqrt{\frac{1}{N} \sum_{i=1}^N (M_i - O_i)^2}$	Reported as %
Gross Error (GE)	$\frac{1}{N} \sum_{i=1}^N \frac{ M_i - O_i }{O_i}$	Reported as %
Mean normalized bias (MNB)	$\frac{1}{N} \sum_{i=1}^N \frac{M_i - O_i}{O_i}$	Reported as %
Mean normalized error (MNE)	$\frac{1}{N} \sum_{i=1}^N \frac{ M_i - O_i }{O_i}$	Reported as %
Mean fractional bias (MFB)	$\frac{2}{N} \sum_{i=1}^N \frac{(M_i - O_i)}{(M_i + O_i)}$	Reported as %
Mean fractional error (MFE)	$\frac{2}{N} \sum_{i=1}^N \frac{ M_i - O_i }{(M_i + O_i)}$	Reported as %

20 Note: * i represents the pairing of N observations O and predictions M by site and time.

Table S4. Model performance of meteorological parameters temperature (T2), wind speed (WS), wind direction and relative humidity (RH) in each season and whole year in China. The values are bolded without meeting the benchmarks. (PRE is prediction; OBS is observation; MB is bias; GE is gross error; and RMSE is root mean square error).

	Statistics	Spring	Summer	Fall	Winter	Year	Benchmarks*
T2 (K)	OBS	287.3	297.3	287.0	273.1	278.7	
	PRE	286.4	296.7	286.3	271.7	278.4	
	MB	-0.8	-0.6	-0.6	-1.4	-0.6	$\leq \pm 0.5$
	GE	2.6	2.3	2.4	3.2	2.4	≤ 2.0
	RMSE	3.7	3.2	3.2	4.3	3.3	
WS (ms ⁻¹)	OBS	3.5	3.2	3.3	3.4	3.4	
	PRE	4.5	3.8	4.1	4.5	4.3	
	MB	0.9	0.5	0.8	1.1	0.9	$\leq \pm 0.5$
	GE	1.7	1.4	1.5	1.7	1.7	≤ 2.0
	RMSE	2.2	1.8	2.0	2.3	2.2	≤ 2.0
WD (°)	OBS	177.5	168.9	167.4	186.2	182.2	
	PRE	184.5	172.7	162.9	187.2	188.3	
	MB	6.9	3.8	3.7	1.0	6.1	$\leq \pm 10$
	GE	44.1	45.2	42.6	43.3	44.8	$\leq \pm 30$
	RMSE	61.1	62.1	59.3	59.8	61.7	
RH (%)	OBS	70.4	69.2	74.4	78.3	71.9	
	PRE	69.9	70.5	74.9	77.0	71.9	
	MB	-0.5	1.2	0.6	-1.2	0.0	
	GE	11.9	11.3	11.2	10.8	11.5	
	RMSE	15.6	14.7	14.6	14.3	15.1	

30 **Table S5. Model performance on maximum daily average 1h (MDA1) O₃ and maximum daily average 8h (MDA8) O₃ in different cases in China and important regions. The values are bolded without meeting the benchmarks. The performance criteria are suggested by EPA (2007). There are 1381 stations shown as purple in Figure S1. (OBS is mean observation; PRE is mean prediction; MNB: mean normalized bias; MNE: mean normalized error; MFB: mean fractional bias; and MFE: mean fractional error).**

Statistics		C1	C2	C3	C4	C5	Benchmarks*
MDA1 O ₃ Cutoff 60 ppb	China	OBS	67.92	67.92	67.92	67.92	
		PRE	70.69	69.35	70.67	67.7	70.36
		MNB	0.05	0.04	0.05	0.02	0.05
		MNE	0.19	0.19	0.19	0.18	0.19
		MFB	0.02	0.0	0.02	-0.01	0.01
		MFE	0.18	0.18	0.18	0.18	0.19
	NCP	OBS	69.12	69.12	69.12	69.12	69.12
		PRE	74.48	72.97	74.45	71.9	73.9
		MNB	0.08	0.07	0.08	0.05	0.08
		MNE	0.2	0.19	0.2	0.18	0.2
		MFB	0.05	0.03	0.05	0.02	0.04
		MFE	0.18	0.18	0.18	0.17	0.18
	YRD	OBS	69.12	69.12	69.12	69.12	69.12
		PRE	73.82	72.4	73.74	69.75	73.24
		MNB	0.08	0.06	0.08	0.03	0.07
		MNE	0.2	0.2	0.2	0.18	0.2
		MFB	0.04	0.02	0.04	0.0	0.03
		MFE	0.19	0.19	0.19	0.18	0.19
	PRD	OBS	72.1	72.1	72.1	72.1	72.1
		PRE	72.69	71.32	72.58	69.69	73.36
		MNB	0.03	0.01	0.02	-0.01	0.03
		MNE	0.19	0.19	0.19	0.18	0.2
		MFB	-0.01	-0.02	-0.01	-0.04	-0.0
		MFE	0.19	0.19	0.19	0.18	0.19
MDA8 O ₃ Cutoff 60 ppb	China	OBS	61.36	61.36	61.36	61.36	61.36
		PRE	63.68	62.27	63.65	60.16	63.27
		MNB	0.04	0.02	0.04	-0.01	0.04
		MNE	0.21	0.2	0.21	0.19	0.21
		MFB	0.05	0.04	0.05	0.02	0.05
		MFE	0.16	0.15	0.16	0.14	0.16
	NCP	OBS	64.55	64.55	64.55	64.55	64.55
		PRE	68.3	66.81	68.26	65.75	67.85
		MNB	0.06	0.04	0.06	0.03	0.06
		MNE	0.23	0.22	0.23	0.21	0.23
		MFB	0.07	0.06	0.07	0.04	0.07
		MFE	0.17	0.16	0.17	0.16	0.17
	YRD	OBS	63.52	63.52	63.52	63.52	63.52
		PRE	69.0	67.29	68.91	63.73	68.02
		MNB	0.08	0.06	0.08	0.01	0.07
		MNE	0.21	0.2	0.21	0.19	0.21
		MFB	0.07	0.06	0.07	0.02	0.06

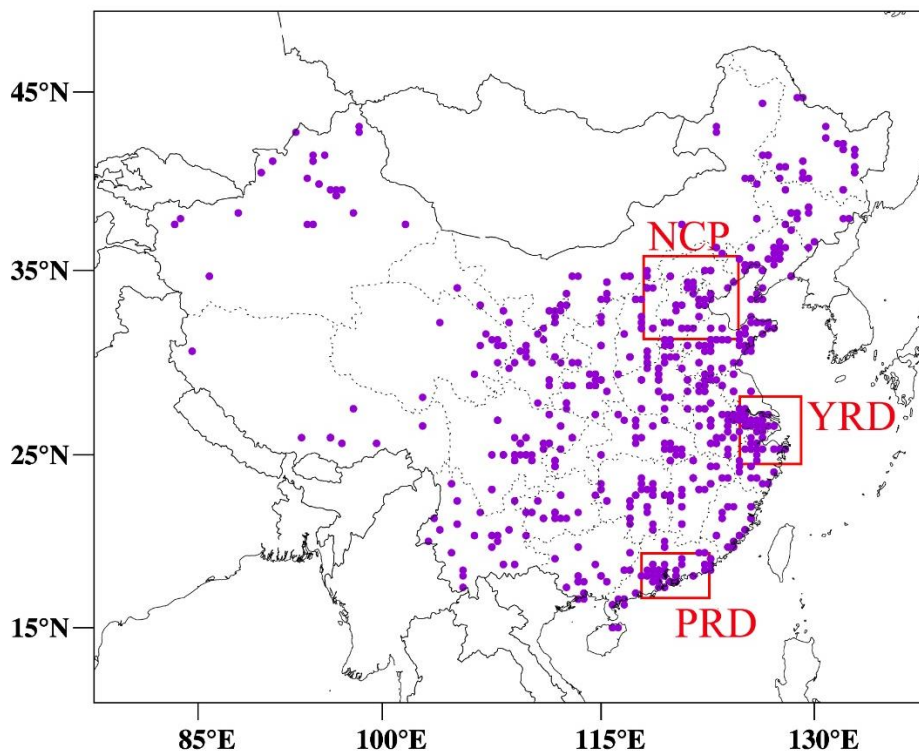
	MFE	0.17	0.17	0.17	0.15	0.17	
	OBS	65.58	65.58	65.58	65.58	65.58	
	PRE	61.74	60.19	61.65	58.35	62.22	
PRD	MNB	-0.04	-0.06	-0.04	-0.09	-0.03	$\leq \pm 0.15$
	MNE	0.25	0.24	0.25	0.24	0.25	≤ 0.3
	MFB	0.04	0.02	0.03	0.0	0.04	
	MFE	0.14	0.14	0.14	0.13	0.14	

35 **Table S6. Model performance $\text{PM}_{2.5}$ pollutants in different cases in China and important regions. There are 1381 stations shown as purple in Figure S1.**

	Statistics	C1	C2	C3	C4	C5	Benchmarks*
$\text{PM}_{2.5}$ ($\mu\text{g m}^{-3}$)	China	OBS	41.51	41.51	41.51	41.51	
		PRE	40.67	40.44	40.64	40.02	
		MNB	0.27	0.27	0.27	0.25	
		MNE	0.73	0.73	0.73	0.72	
		MFB	-0.11	-0.11	-0.11	-0.13	$\leq \pm 0.6$
		MFE	0.57	0.57	0.57	0.57	≤ 0.75
	NCP	OBS	48.92	48.92	48.92	48.92	
		PRE	47.85	47.63	47.85	47.42	
		MNB	0.31	0.31	0.31	0.3	
		MNE	0.69	0.68	0.69	0.68	
		MFB	-0.03	-0.03	-0.03	-0.04	$\leq \pm 0.6$
		MFE	0.5	0.5	0.5	0.5	≤ 0.75
	YRD	OBS	43.67	43.67	43.67	43.67	
		PRE	48.15	47.87	48.12	47.3	
		MNB	0.36	0.36	0.36	0.34	
		MNE	0.7	0.7	0.7	0.69	
		MFB	0.01	0.01	0.01	-0.01	$\leq \pm 0.6$
		MFE	0.48	0.48	0.48	0.49	≤ 0.75
	PRD	OBS	32.85	32.85	32.85	32.85	
		PRE	33.69	33.46	33.63	32.93	
		MNB	0.28	0.27	0.28	0.25	
		MNE	0.77	0.77	0.77	0.77	
		MFB	-0.12	-0.13	-0.12	-0.15	$\leq \pm 0.6$
		MFE	0.59	0.6	0.6	0.61	≤ 0.75

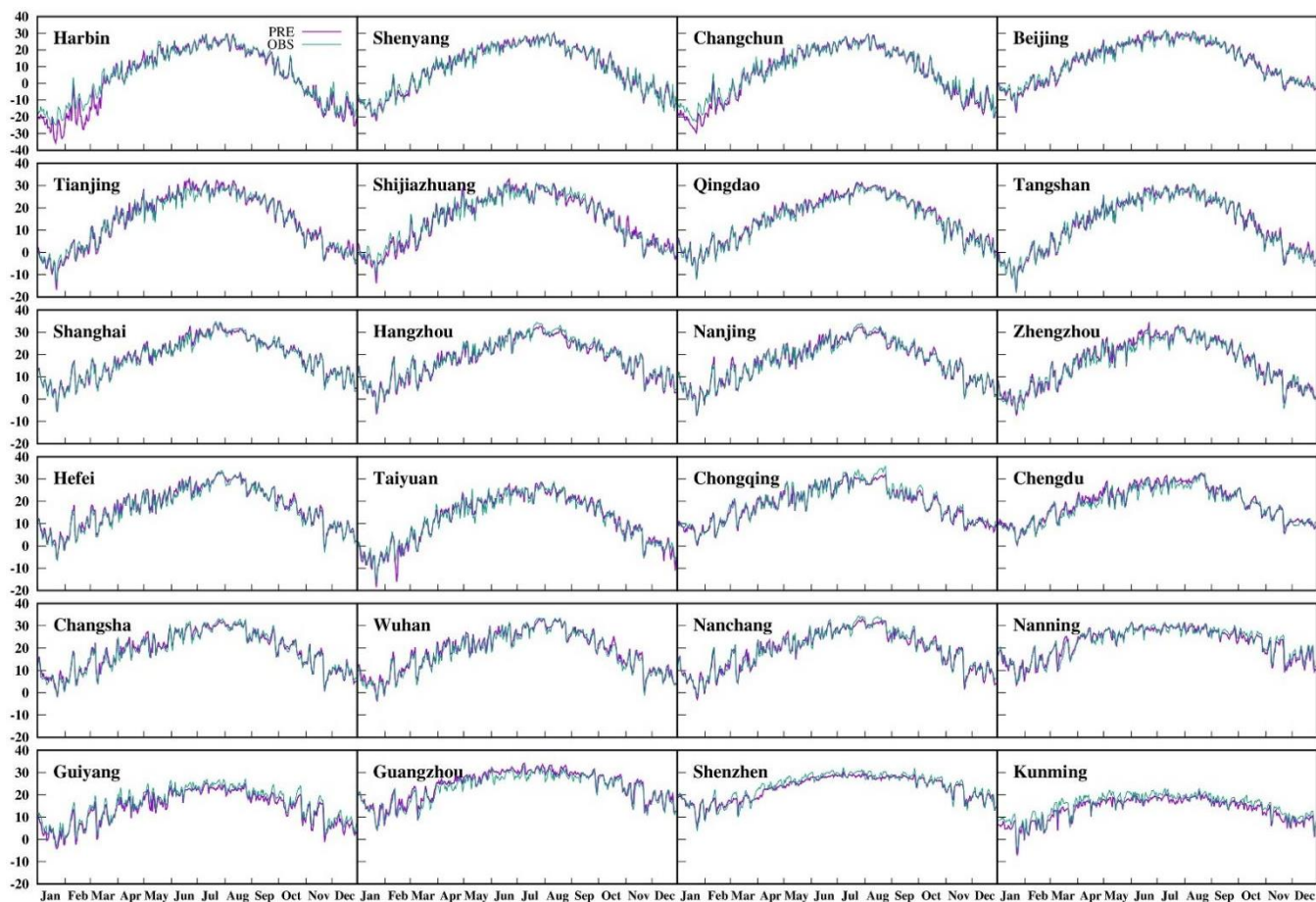
Table S6. Seasonal averaged temperature in important regions of China. Unit is $^{\circ}\text{C}$.

	Spring	Summer	Fall	Winter
NCP	14.4	25.8	14.2	-0.6
YRD	16.2	26.9	18.2	6.0
PRD	22.6	28.7	24.2	15.0



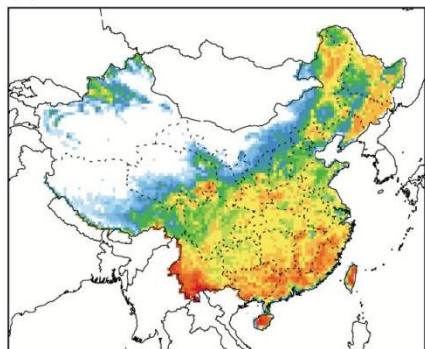
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Figure S1. Model domain with the key city clusters (North China Plain, NCP; Yangtze River Delta, YRD; Pearl River Delta, PRD). Purple-filled circles show locations of air quality monitoring sites (1381 sites in total).

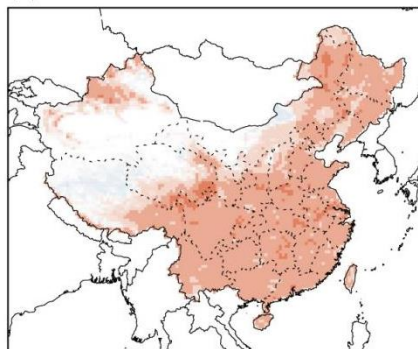


45 **Figure S2. Comparison of observed and predicted daily averaged 2m temperature in each city.**

(a) GLASS



(b) GLASS-MOD15



(c) GLASS-CGLS

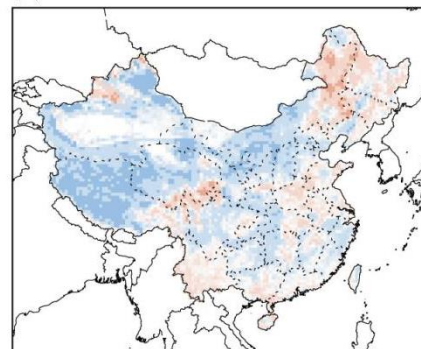
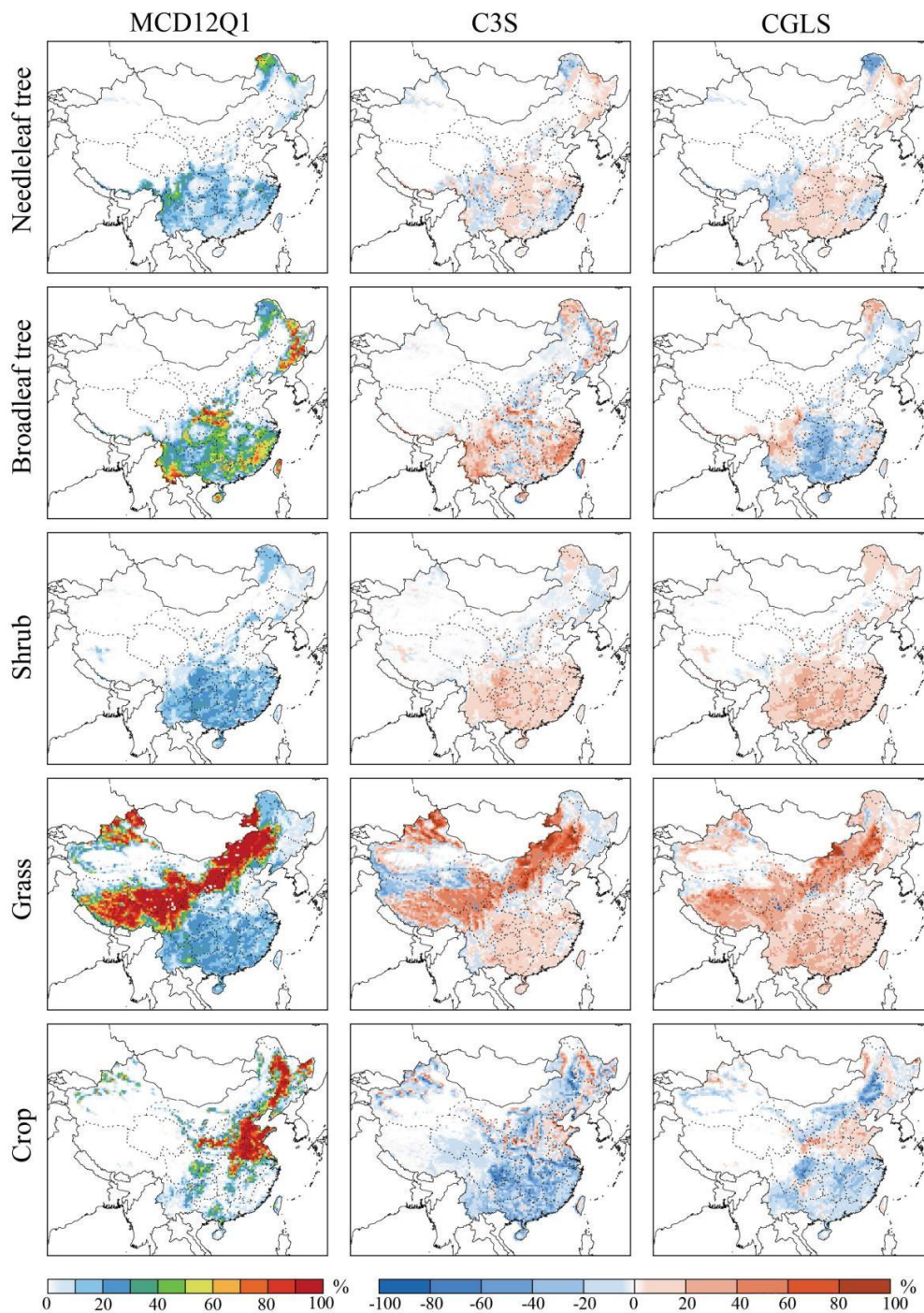


Figure S3. Distribution of LAIv from different satellite datasets in 2016.



50 **Figure S4. The cover fraction of different PFTs in the MCD12Q1 product and the difference between the MCD12Q1 and the other satellite products for the year 2016.**

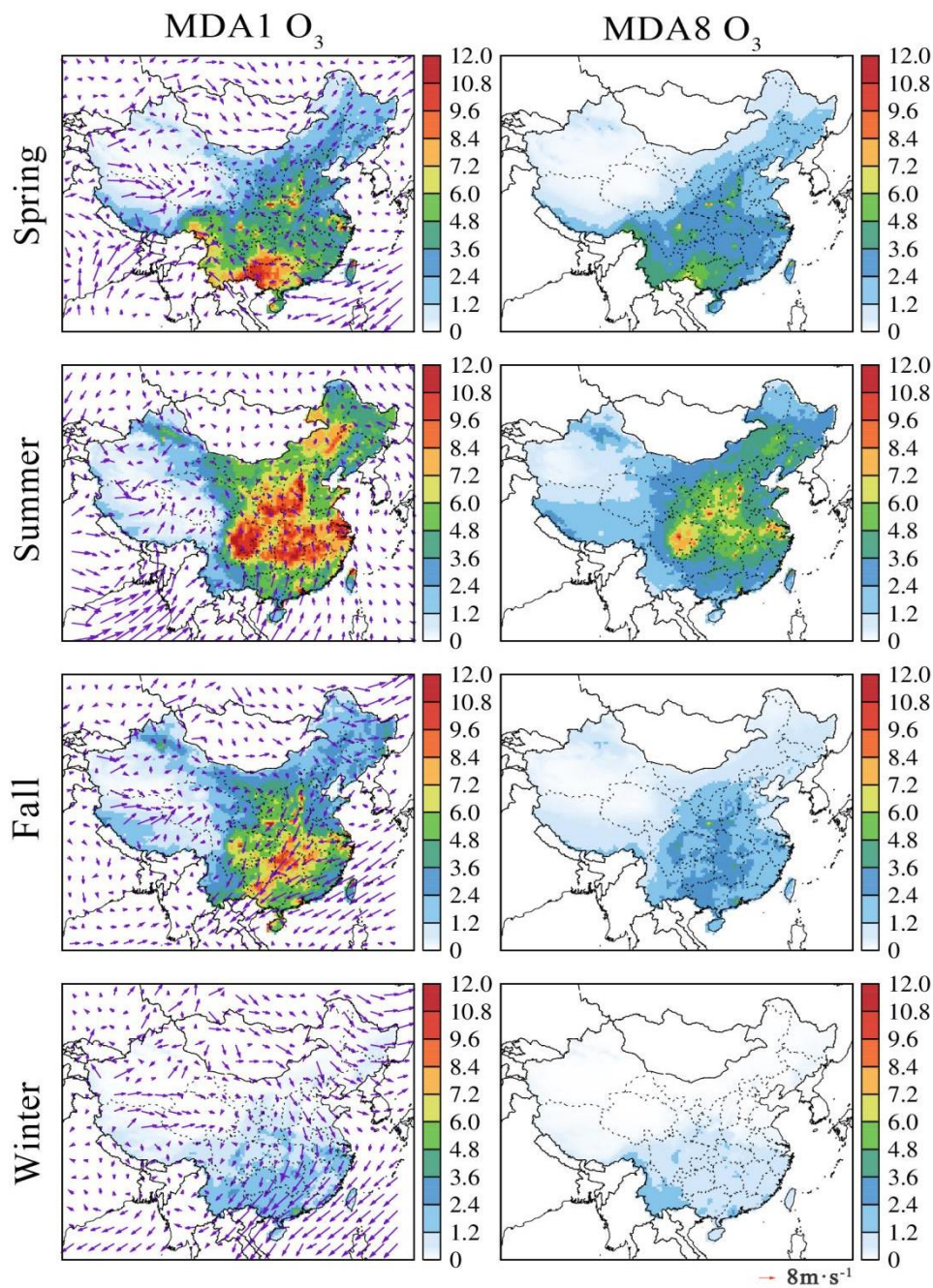


Figure S5. Seasonal spatial variation of predicted MDA1 O₃ and MDA8 O₃ formed by BVOCs and wind vectors. C1 is chosen as the input data to draw these maps. Unit is ppb.

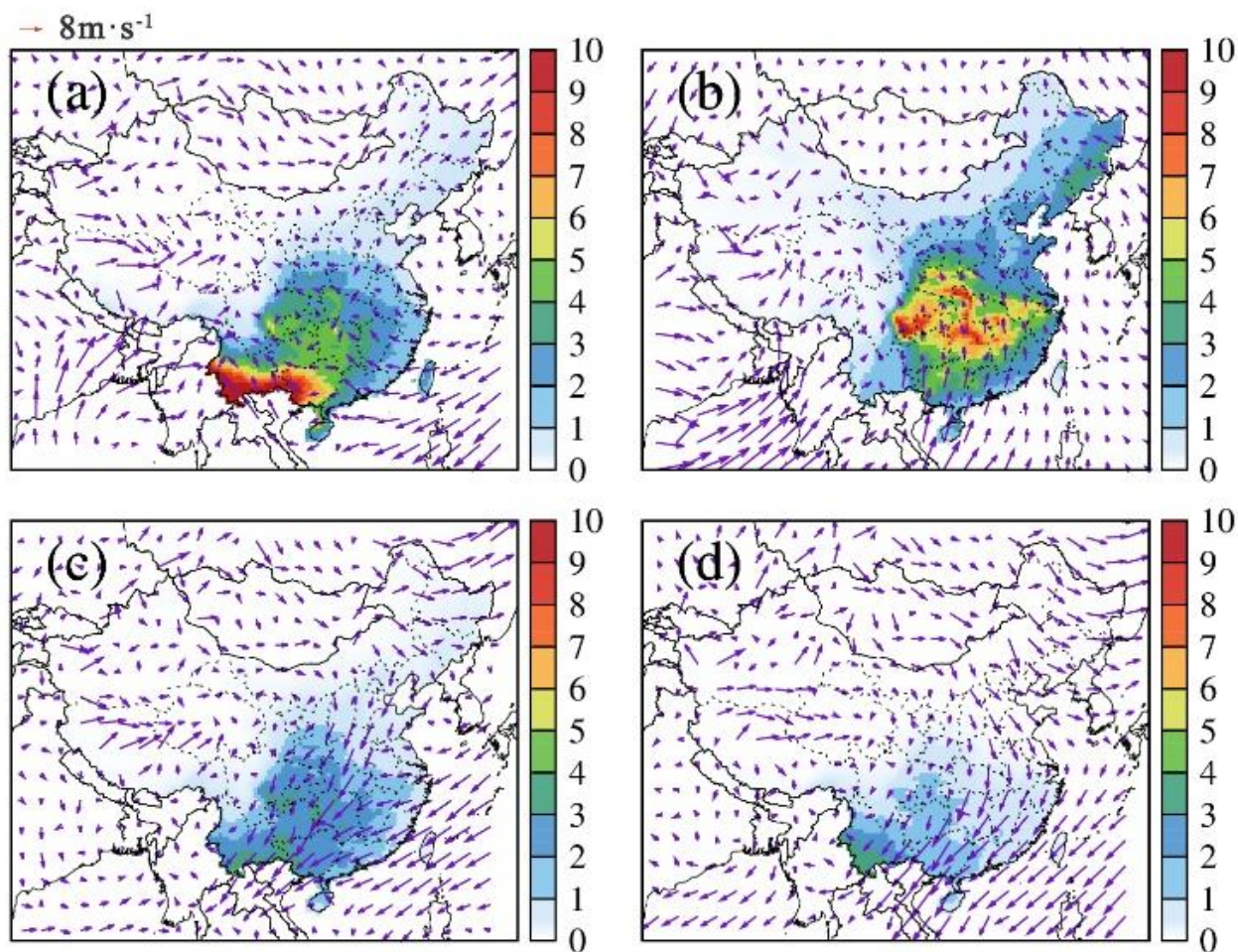


Figure S6. Seasonal spatial variation of predicted SOA formed by BVOCs and wind vectors ((a) Spring, (b) Summer, (c) Fall, (d) Winter). C5 is chosen as the input data to draw these maps. Unit is $\mu\text{g m}^{-3}$.

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