



*Supplement of*

## **Impacts of land cover changes on biogenic emission and its contribution to ozone and secondary organic aerosol in China**

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**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	Year	Temporal Resolution	Spatial Resolution	Source
MODIS MCD12Q1	2001-2021	Yearly	500 m	Available at <a href="https://search.earthdata.nasa.gov/">https://search.earthdata.nasa.gov/</a> , last access: 10 April 2022
C3S LC	1992-2021	Yearly	300 m	Available at <a href="https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-land-cover?tab=form">https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-land-cover?tab=form</a> , last access: 21 March 2022
CGLS LC	2015-2019	Yearly	100 m	Available at <a href="https://land.copernicus.eu/global/products/lc">https://land.copernicus.eu/global/products/lc</a> , last access: 15 April 2022
MODIS MOD15	2000-2021	8 days	500 m	Available at <a href="https://search.earthdata.nasa.gov/">https://search.earthdata.nasa.gov/</a> , last access: 10 April 2022
GLASS	2000-2021	8 days	500 m	Available at <a href="http://www.glass.umd.edu/LAI/MODIS/">http://www.glass.umd.edu/LAI/MODIS/</a> , last access: 11 April 2022
CGLS	2014-2021	10 days	300 m	Available at <a href="https://land.copernicus.eu/global/products/lai">https://land.copernicus.eu/global/products/lai</a> , last access: 10 April 2022

5 **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 %

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 without meeting the benchmarks are bolded.**

10 (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	<b>-0.8</b>	<b>-0.6</b>	<b>-0.6</b>	<b>-1.4</b>	<b>-0.6</b>	$\leq \pm 0.5$
	GE	<b>2.6</b>	<b>2.3</b>	<b>2.4</b>	<b>3.2</b>	<b>2.4</b>	$\leq 2.0$
	RMSE	3.7	3.2	3.2	4.3	3.3	
WS (ms <sup>-1</sup> )	OBS	3.5	3.2	3.3	3.4	3.4	
	PRE	4.5	3.8	4.1	4.5	4.3	
	MB	<b>0.9</b>	0.5	<b>0.8</b>	<b>1.1</b>	<b>0.9</b>	$\leq \pm 0.5$
	GE	1.7	1.4	1.5	1.7	1.7	$\leq 2.0$
	RMSE	<b>2.2</b>	1.8	2.0	<b>2.3</b>	<b>2.2</b>	$\leq 2.0$
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	<b>44.1</b>	<b>45.2</b>	<b>42.6</b>	<b>43.3</b>	<b>44.8</b>	$\leq \pm 30$
	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	

Note: \* are benchmarks suggested by Emery et al. (2001).

15 **Table S5. Model performance on maximum daily average 1h (MDA1) O<sub>3</sub> and maximum daily average 8h (MDA8) O<sub>3</sub> in different cases in China and important regions. The values without meeting the criteria are bolded. 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). The unit for O<sub>3</sub> is ppb.**

	Statistics	C1	C2	C3	C4	C5	Criteria*	
MDA1 O <sub>3</sub> Cutoff 60 ppb		OBS	67.92	67.92	67.92	67.92	67.92	
		PRE	70.69	69.35	70.67	67.7	70.36	
	China	MNB	0.05	0.04	0.05	0.02	0.05	≤±0.15
		MNE	0.19	0.19	0.19	0.18	0.19	≤0.3
		MFB	0.02	0.0	0.02	-0.01	0.01	
		MFE	0.18	0.18	0.18	0.18	0.19	
		OBS	69.12	69.12	69.12	69.12	69.12	
		PRE	74.48	72.97	74.45	71.9	73.9	
	NCP	MNB	0.08	0.07	0.08	0.05	0.08	≤±0.15
		MNE	0.2	0.19	0.2	0.18	0.2	≤0.3
		MFB	0.05	0.03	0.05	0.02	0.04	
		MFE	0.18	0.18	0.18	0.17	0.18	
		OBS	69.12	69.12	69.12	69.12	69.12	
		PRE	73.82	72.4	73.74	69.75	73.24	
	YRD	MNB	0.08	0.06	0.08	0.03	0.07	≤±0.15
		MNE	0.2	0.2	0.2	0.18	0.2	≤0.3
		MFB	0.04	0.02	0.04	0.0	0.03	
		MFE	0.19	0.19	0.19	0.18	0.19	
	OBS	72.1	72.1	72.1	72.1	72.1		
	PRE	72.69	71.32	72.58	69.69	73.36		
PRD	MNB	0.03	0.01	0.02	-0.01	0.03	≤±0.15	
	MNE	0.19	0.19	0.19	0.18	0.2	≤0.3	
	MFB	-0.01	-0.02	-0.01	-0.04	-0.0		
	MFE	0.19	0.19	0.19	0.18	0.19		
	OBS	61.36	61.36	61.36	61.36	61.36		
	PRE	63.68	62.27	63.65	60.16	63.27		

MDA8 O <sub>3</sub> Cutoff 60 ppb	China	MNB	0.04	0.02	0.04	-0.01	0.04	≤±0.15	
		MNE	0.21	0.2	0.21	0.19	0.21	≤0.3	
		MFB	0.05	0.04	0.05	0.02	0.05		
		MFE	0.16	0.15	0.16	0.14	0.16		
			OBS	64.55	64.55	64.55	64.55	64.55	
			PRE	68.3	66.81	68.26	65.75	67.85	
	NCP	MNB	0.06	0.04	0.06	0.03	0.06	≤±0.15	
		MNE	0.23	0.22	0.23	0.21	0.23	≤0.3	
		MFB	0.07	0.06	0.07	0.04	0.07		
		MFE	0.17	0.16	0.17	0.16	0.17		
			OBS	63.52	63.52	63.52	63.52	63.52	
			PRE	69.0	67.29	68.91	63.73	68.02	
	YRD	MNB	0.08	0.06	0.08	0.01	0.07	≤±0.15	
		MNE	0.21	0.2	0.21	0.19	0.21	≤0.3	
		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	≤±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			

Note: \* are criteria suggested by EPA (2007).

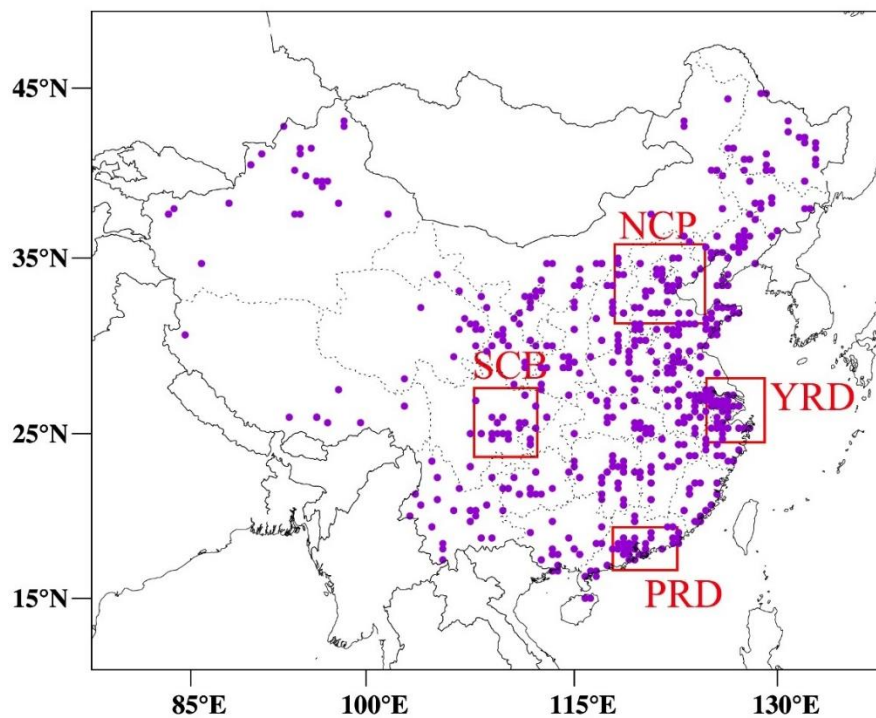
20 **Table S6. Model performance PM<sub>2.5</sub> pollutants in different cases in China and important regions. There are 1381 stations shown as purple in Figure S1.**

	Statistics	C1	C2	C3	C4	C5	Criteria*	
PM <sub>2.5</sub> ( $\mu\text{g m}^{-3}$ )	China	OBS	41.51	41.51	41.51	41.51	41.51	
		PRE	40.67	40.44	40.64	40.02	40.6	
		MNB	0.27	0.27	0.27	0.25	0.27	
		MNE	0.73	0.73	0.73	0.72	0.73	
		MFB	-0.11	-0.11	-0.11	-0.13	-0.11	$\leq \pm 0.6$
		MFE	0.57	0.57	0.57	0.57	0.56	$\leq 0.75$
	NCP	OBS	48.92	48.92	48.92	48.92	48.92	
		PRE	47.85	47.63	47.85	47.42	47.79	
		MNB	0.31	0.31	0.31	0.3	0.31	
		MNE	0.69	0.68	0.69	0.68	0.69	
		MFB	-0.03	-0.03	-0.03	-0.04	-0.03	$\leq \pm 0.6$
		MFE	0.5	0.5	0.5	0.5	0.5	$\leq 0.75$
	YRD	OBS	43.67	43.67	43.67	43.67	43.67	
		PRE	48.15	47.87	48.12	47.3	48.02	
		MNB	0.36	0.36	0.36	0.34	0.36	
		MNE	0.7	0.7	0.7	0.69	0.7	
		MFB	0.01	0.01	0.01	-0.01	0.01	$\leq \pm 0.6$
		MFE	0.48	0.48	0.48	0.49	0.48	$\leq 0.75$
PRD	OBS	32.85	32.85	32.85	32.85	32.85		
	PRE	33.69	33.46	33.63	32.93	33.76		
	MNB	0.28	0.27	0.28	0.25	0.28		
	MNE	0.77	0.77	0.77	0.77	0.77		
	MFB	-0.12	-0.13	-0.12	-0.15	-0.12	$\leq \pm 0.6$	
	MFE	0.59	0.6	0.6	0.61	0.59	$\leq 0.75$	

Note: \* are criteria suggested by Boylan and Russell (2006).

**Table S7. Seasonal averaged temperature in important regions of China. Unit is °C.**

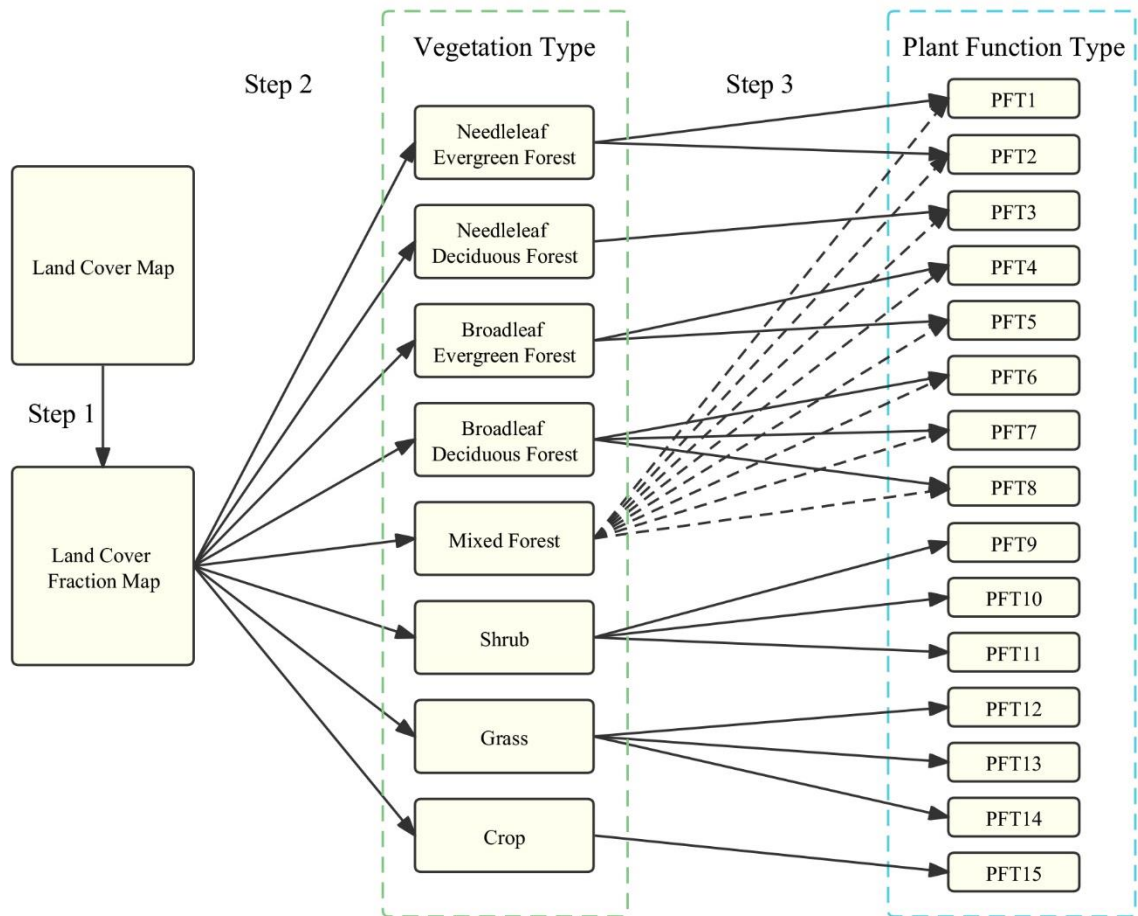
	Spring	Summer	Fall	Winter
NCP	14.4	25.8	14.2	-0.6
YRD	16.2	26.9	18.2	6.0
PRD	22.6	28.7	24.2	15.0



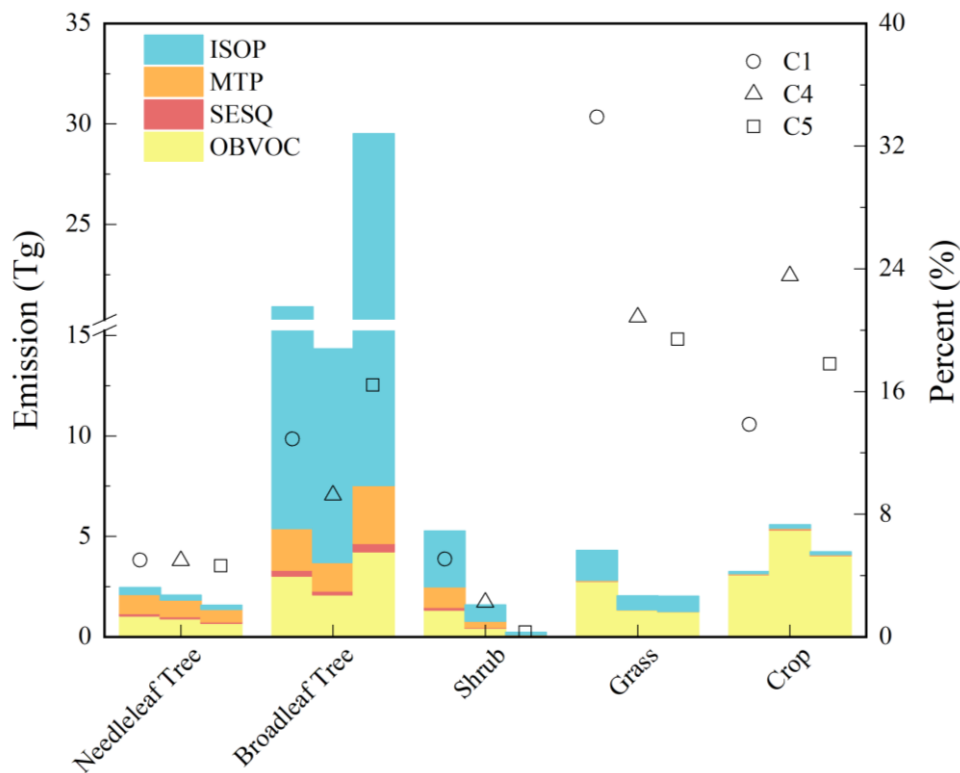
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Figure S1. Model domain with the key city clusters (North China Plain, NCP; Yangtze River Delta, YRD; Pearl River Delta, PRD; Sichuan Basin, SCB). Purple-filled circles show locations of air quality monitoring sites (1381 sites in total).





30 **Figure S2. The flow chart for making plant function type (PFT). The dashed line represents the complementary classification for PFT1 to PFT8.**



35 **Figure S3. The BVOC emissions and vegetation fractions of needleleaf tree, broadleaf tree, shrub, grass, and crop in the C1, C4 and C5. ISOP is isoprene, MTP is monoterpene, SESQ is sesquiterpene and OBVOC is other BVOCs.**

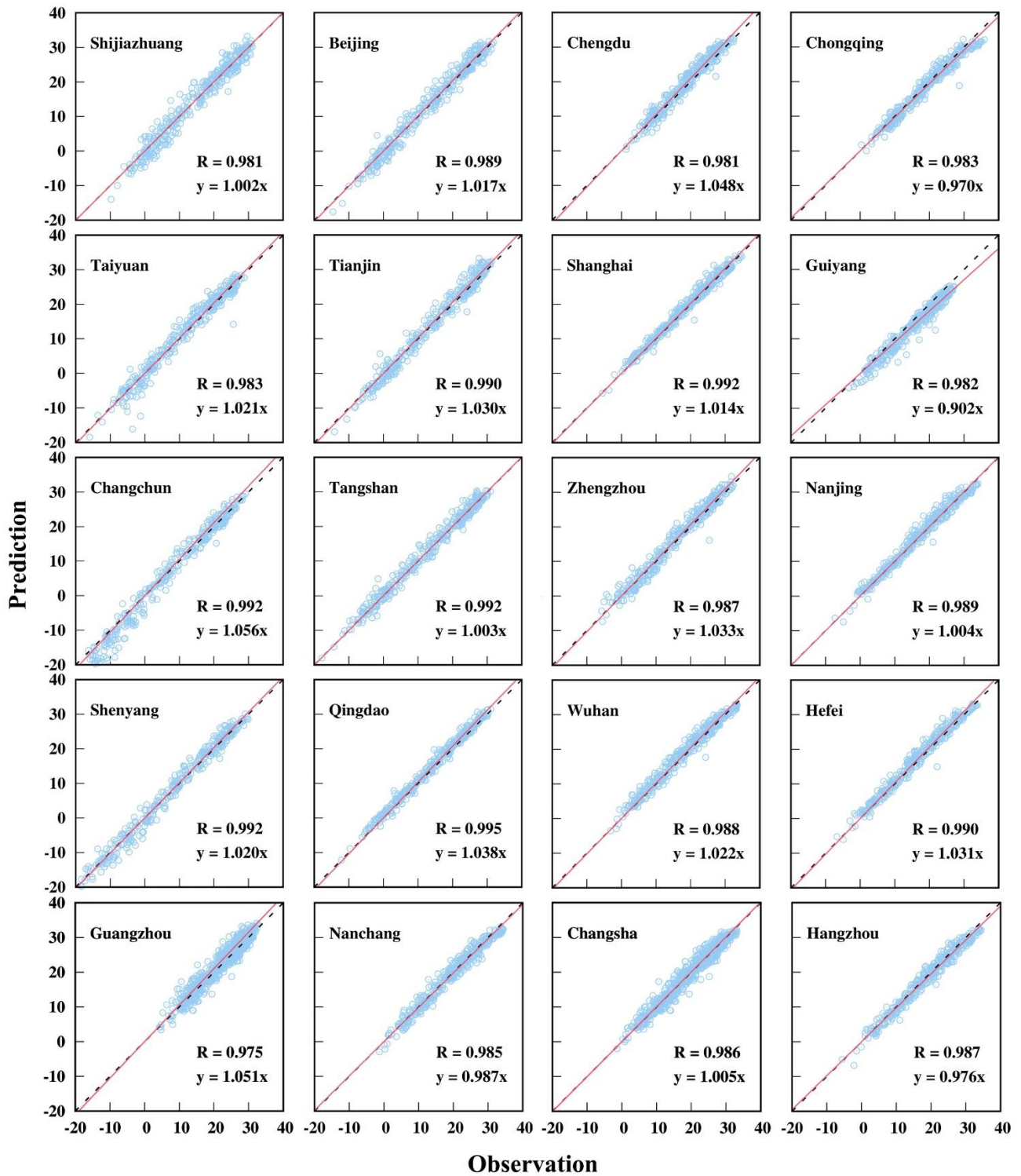
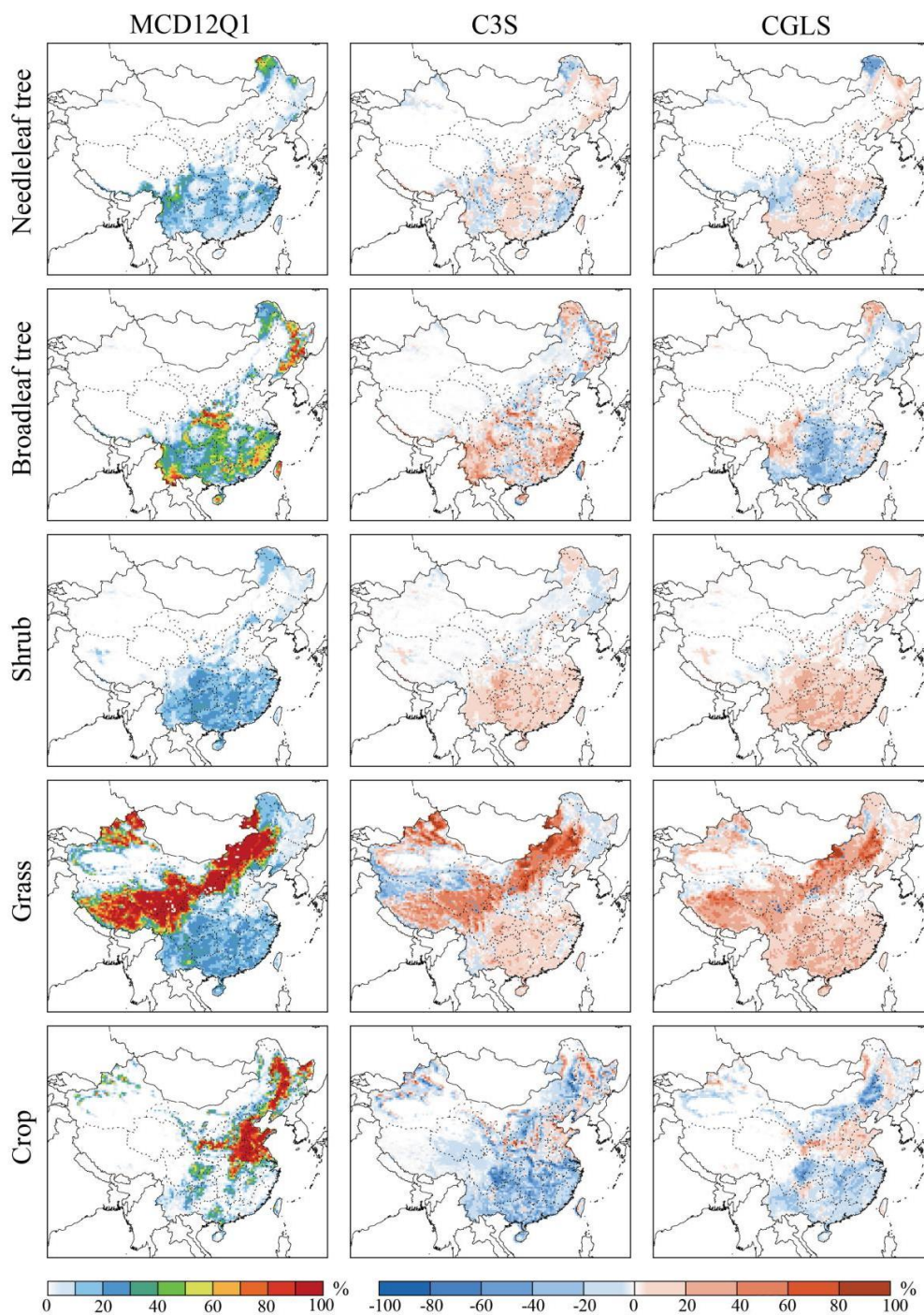
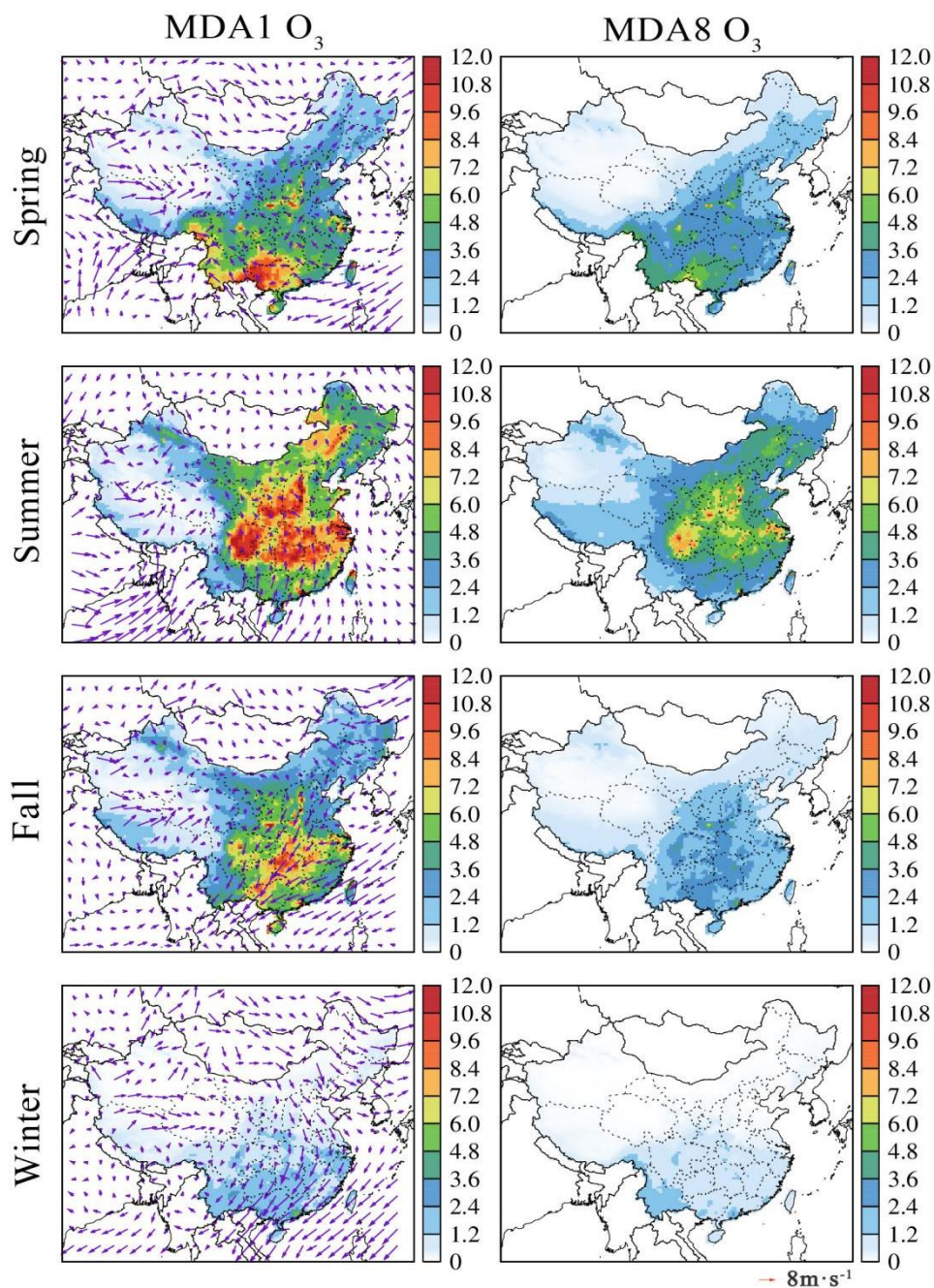


Figure S4. Comparison of observed and predicted daily averaged 2m temperature in each city.



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**Figure S5. 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.**



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Figure S6. Seasonal spatial variation of predicted MDA1 O<sub>3</sub> and MDA8 O<sub>3</sub> formed by BVOCs and wind vectors. C1 is chosen as the input data to draw these maps. Unit is ppb.

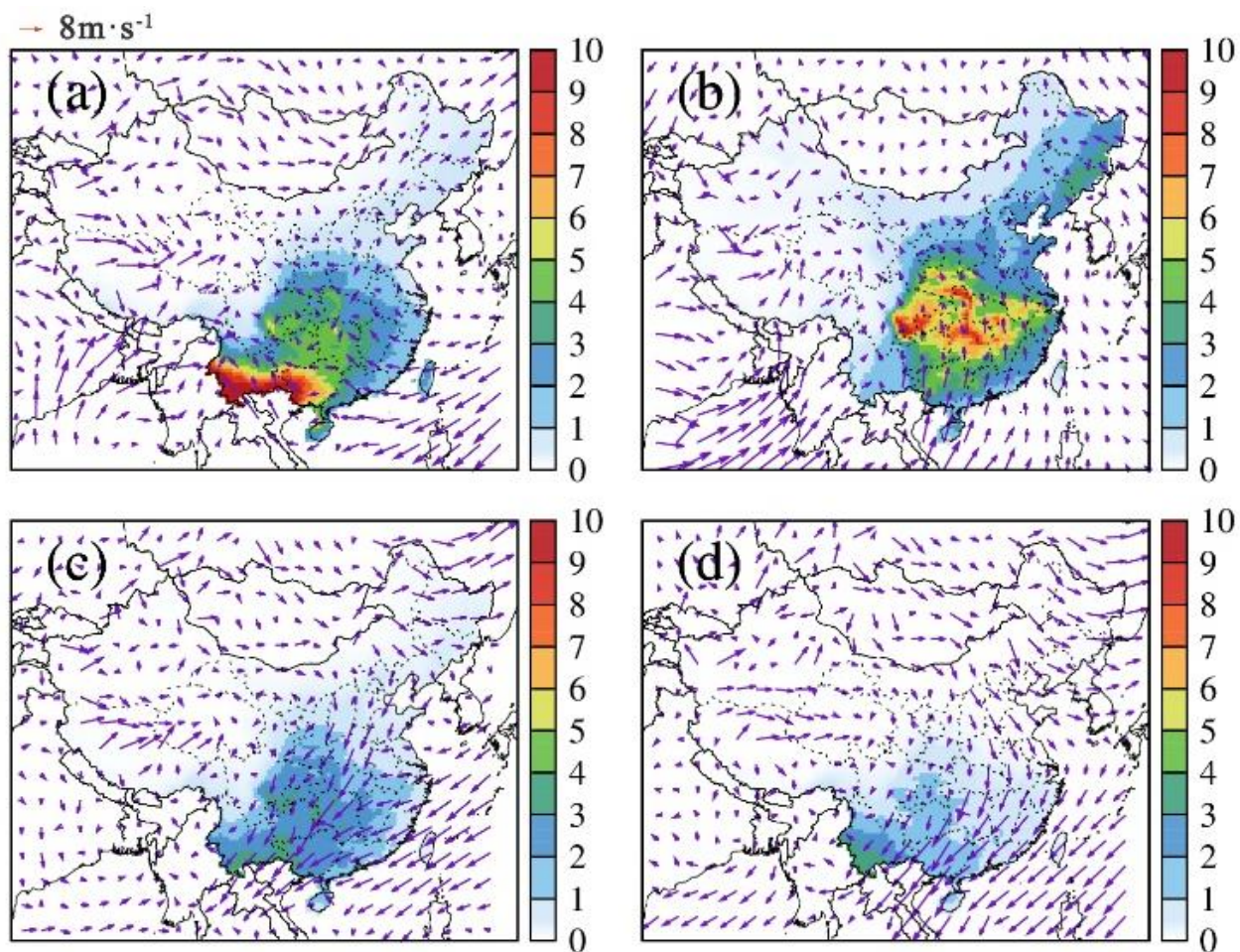
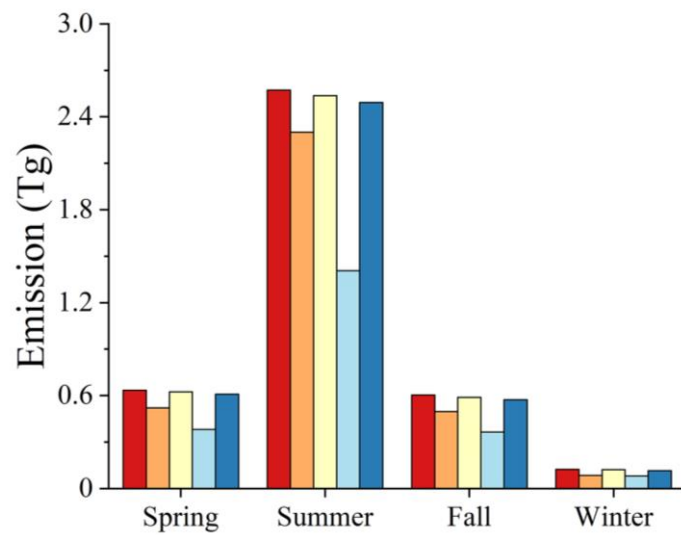


Figure S7. Seasonal spatial variation of predicted SOA formed by BVOCs and wind vectors ((a) Spring, (b) Summer, (c) Fall, (d) Winter). C5 is chosen as the input data to draw these maps. Unit is  $\mu\text{g m}^{-3}$ .



**Figure S8. Seasonal spatial variation of BVOCs in the YRD.**

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