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## **Relative effects of open biomass burning and open crop straw burning on haze formation over central and eastern China: modeling study driven by constrained emissions**

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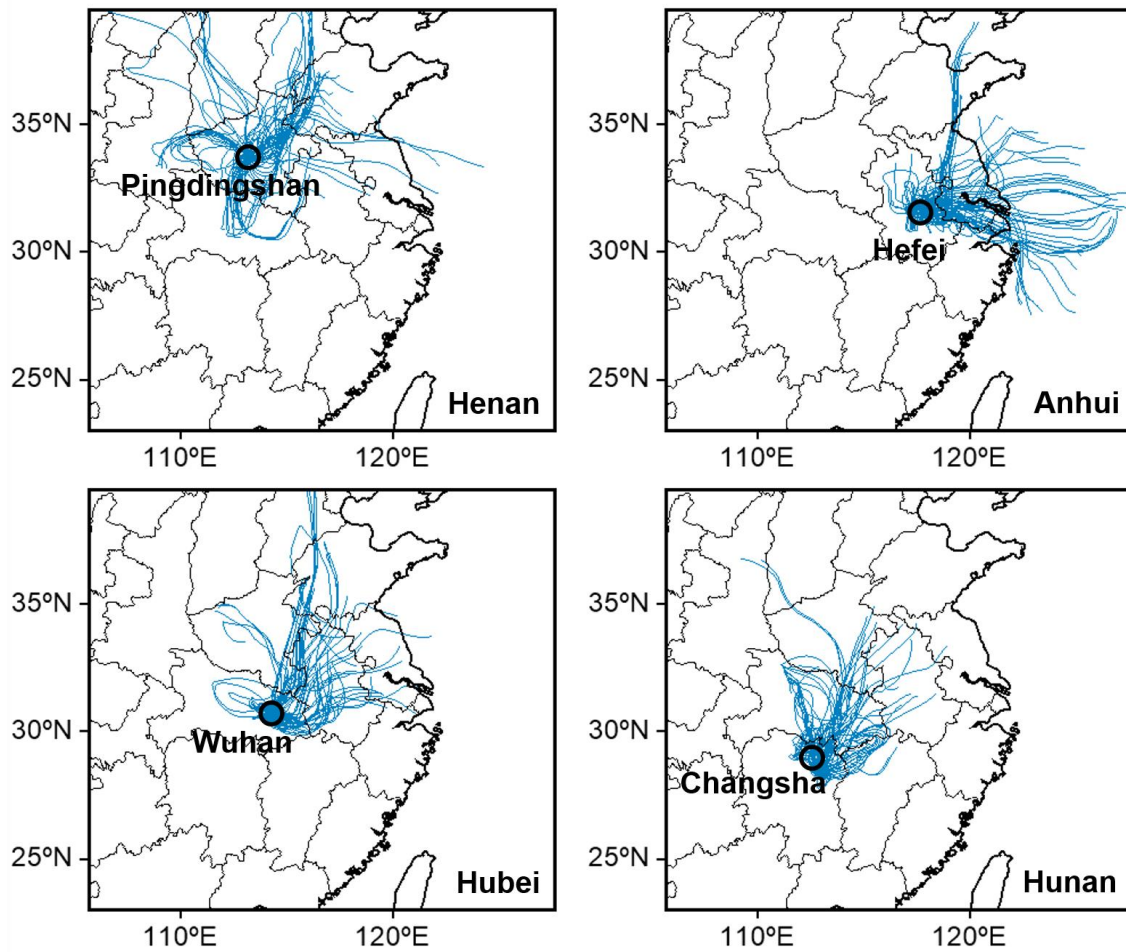


Figure S1. 48h backward trajectories during EP2 for four representative cities (Pingdingshan, Hefei, Wuhan and Changsha) for Henan, Anhui, Hubei and Hunan.

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15 **Table S1. The fire-related parameters (i.e.,  $B_{\text{size}}$ ,  $P_{\text{topmax}}$ , and  $P_{\text{bottommax}}$ ) as a function of the fire size classes.**

Fire Class	1	2	3	4	5
Size	0~10	10~100	100~1000	1000~5000	>5000
$B_{\text{size}}$	0.4	0.6	0.75	0.85	0.9
$P_{\text{topmax}}$	160	2400	6400	7200	8000
$P_{\text{bottommax}}$	0	900	2200	3000	300

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45 **Table S2. The activity related parameter (i.e.,  $B_{\text{hour}}$ ) as a function of hour of day.**

Hour	$B_{\text{hour}}$	Hour	$B_{\text{hour}}$
0	0.03	12	0.7
1	0.03	13	0.8
2	0.03	14	0.9
3	0.03	15	0.95
4	0.03	16	0.99
5	0.03	17	0.8
6	0.03	18	0.7
7	0.03	19	0.4
8	0.06	20	0.06
9	0.1	21	0.03
10	0.2	22	0.03
11	0.4	23	0.03

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**Table S3. Detailed information for 5 monitoring sites of PM<sub>2.5</sub> composition.**

Station	Province	Latitude (E)	Longitude (N)	Altitude (m)	Station Type	PM <sub>2.5</sub> Compositions
Changsha	Hunan	113.06	28.21	45	Urban	
Qianyanzhou	Jiangxi	115.07	26.75	76	Rural/suburban	
Wuxi	Jiangsu	120.35	31.5	5	Urban	K <sup>+</sup> , SO <sub>4</sub> <sup>2-</sup> , NO <sub>3</sub> <sup>-</sup> , OC, and NH <sub>4</sub> <sup>+</sup>
Yucheng	Shandong	116.6	36.95	22	Rural/suburban	
Hefei	Anhui	117.27	31.86	24	Urban	

70 Table S4. Original OBB and OCSB emissions estimated in FINNv1.5 for EP1 ~ EP3 over CEC (Units: million moles for NMVOCs, SO<sub>2</sub>, CO, NH<sub>3</sub>, and NO<sub>x</sub> and tons for EC, OC, primary PM<sub>2.5</sub> and PM<sub>10</sub>).

Episode	Provinces	OBB									OCSB								
		NMVOCs	SO <sub>2</sub>	CO	NH <sub>3</sub>	NO <sub>x</sub>	EC	OC	PM <sub>2.5</sub>	PM <sub>10</sub>	NMVOCs	SO <sub>2</sub>	CO	NH <sub>3</sub>	NO <sub>x</sub>	EC	OC	PM <sub>2.5</sub>	PM <sub>10</sub>
EP1	Shanghai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jiangsu	8	0	29	1	1	5	25	44	54	8	0	28	1	1	5	23	41	49
	Zhejiang	30	1	182	6	4	26	287	553	634	11	0	38	1	1	7	31	55	67
	Anhui	16	0	61	2	2	11	55	97	118	16	0	57	2	2	10	47	83	100
	Fujian	21	0	119	4	4	19	161	305	364	13	0	45	2	2	8	37	66	79
	Jiangxi	17	0	98	3	3	16	146	263	311	10	0	36	1	1	6	30	53	64
	Shandong	37	0	136	4	5	24	116	208	254	36	0	128	4	5	22	106	187	226
	Henan	80	0	289	10	11	50	245	434	528	79	0	279	10	10	49	232	408	494
	Hubei	20	0	79	3	3	14	77	133	163	19	0	69	2	3	12	57	101	122
	Hunan	2	0	9	0	0	2	10	17	21	2	0	7	0	0	1	6	11	13
EP2	Shanghai	12	0	52	2	2	9	57	98	122	11	0	39	1	1	7	32	57	69
	Jiangsu	221	1	812	27	30	141	710	1260	1536	215	1	762	26	28	133	634	1115	1349
	Zhejiang	79	1	439	14	13	69	626	1154	1357	48	0	171	6	6	30	143	251	304
	Anhui	1355	8	4834	164	179	841	4067	7161	8678	1347	8	4778	163	177	832	3979	6993	8464
	Fujian	48	1	311	10	9	46	499	938	1111	17	0	59	2	2	10	49	86	105
	Jiangxi	26	1	163	5	4	24	260	488	567	10	0	36	1	1	6	30	52	63
	Shandong	262	2	950	32	35	166	804	1425	1733	259	1	919	31	34	160	766	1346	1629
	Henan	833	5	2983	101	111	519	2500	4411	5351	829	5	2941	100	109	512	2449	4304	5209
	Hubei	13	0	54	2	2	9	60	108	129	11	0	39	1	1	7	32	56	68
	Hunan	14	0	84	3	2	13	128	239	281	7	0	24	1	1	4	20	35	42
EP3	Shanghai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jiangsu	7	0	29	1	1	5	29	51	62	7	0	24	1	1	4	20	35	43
	Zhejiang	12	0	64	2	2	10	93	177	205	6	0	21	1	1	4	18	31	38
	Anhui	38	0	138	5	5	24	117	208	253	37	0	132	5	5	23	110	194	235
	Fujian	3	0	20	1	1	3	27	47	59	2	0	8	0	0	1	7	12	14
	Jiangxi	30	1	197	6	5	29	321	603	697	10	0	37	1	1	6	30	53	65
	Shandong	7	0	28	1	1	5	25	45	55	7	0	24	1	1	4	20	35	42
	Henan	15	0	56	2	2	10	47	84	102	15	0	54	2	2	9	45	78	95
	Hubei	4	0	14	0	1	2	14	26	32	3	0	11	0	0	2	9	16	19
	Hunan	27	1	200	6	5	28	339	649	748	5	0	16	1	1	3	14	24	29

**Table S5. The comparisons of the simulated PM<sub>2.5</sub> composition ( $\mu\text{g m}^{-3}$ ) in the BASE and OPT cases with the observations (OBS) as well as their corresponding NMB values (%).**

Composition	Time periods		Changsha		Hefei		Yucheng		Qianyanzhou		Wuxi	
			Values	NMB	Values	NMB	Values	NMB	Values	NMB	Values	NMB
K <sup>+</sup>	From 10 a.m., June 2 to 10 a.m., June 4	OBS	0.59		0.92		0.90		0.09		0.62	
		BASE	0.15	-74.64	0.18	-80.53	0.35	-61.12	0.22	149.12	0.12	-80.73
		OPT	0.21	-64.50	0.28	-69.71	0.45	-50.01	0.25	183.09	0.13	-79.12
	From 10 a.m., June 9 to 10 a.m., June 11	OBS	1.50		1.16		1.49		0.56		0.56	
		BASE	0.49	-67.34	0.55	-52.49	0.78	-47.67	0.41	-26.80	0.38	-32.23
		OPT	0.79	-47.34	0.89	-23.12	0.87	-41.63	0.45	-19.65	0.34	-39.37
	From 10 a.m., June 16 to 10 a.m., June 18	OBS	0.51		0.91		0.51		0.16		0.25	
		BASE	0.34	-33.36	0.54	-40.52	0.71	39.78	0.29	77.65	0.07	-72.05
		OPT	0.38	-25.52	0.78	-14.09	0.74	45.68	0.33	102.15	0.09	-64.07
SO <sub>4</sub> <sup>2-</sup>	From 10 a.m., June 2 to 10 a.m., June 4	OBS	20.48		10.95		13.11		12.56		16.21	
		BASE	11.40	-44.34	5.90	-46.12	8.70	-33.64	1.98	-84.24	9.64	-40.54
		OPT	24.12	17.77	13.54	23.64	15.34	17.01	3.45	-72.53	9.58	-40.91
	From 10 a.m., June 9 to 10 a.m., June 11	OBS	33.83		18.68		30.74		8.97		13.23	
		BASE	20.14	-40.47	14.70	-21.31	15.98	-48.01	2.55	-71.56	8.40	-36.53
		OPT	37.07	9.57	22.30	19.38	31.99	4.07	3.54	-60.52	9.00	-31.99
	From 10 a.m., June 16 to 10 a.m., June 18	OBS	18.94		27.05		21.86		20.95		12.00	
		BASE	13.75	-27.39	16.70	-38.26	8.71	-60.15	4.78	-77.19	6.85	-42.90
		OPT	23.64	24.83	28.90	6.85	18.05	-17.41	5.61	-73.23	7.40	-38.31
NO <sub>3</sub> <sup>-</sup>	From 10 a.m., June 2 to 10 a.m., June 4	OBS	9.34		8.48		7.49		1.93		6.35	
		BASE	10.97	17.49	5.39	-36.44	3.61	-51.81	1.03	-46.56	1.78	-71.96
		OPT	14.98	60.44	9.81	15.67	6.45	-13.90	2.62	35.94	1.95	-69.28
	From 10 a.m., June 9 to 10 a.m., June 11	OBS	11.57		3.20		12.72		0.60		1.82	
		BASE	9.70	-16.18	7.90	146.66	10.80	-15.13	1.85	207.90	0.98	-46.05
		OPT	12.45	7.58	8.50	165.40	14.45	13.56	2.95	390.98	0.97	-46.60
	From 10 a.m., June 16 to 10 a.m., June 18	OBS	4.85		28.33		15.89		2.22		12.27	
		BASE	7.40	52.45	20.00	-29.39	20.38	28.23	1.88	-15.36	14.95	21.82
		OPT	8.78	80.88	29.80	5.21	21.09	32.69	2.23	0.40	15.78	28.59
NH <sub>4</sub> <sup>+</sup>	From 10 a.m., June 2 to 10 a.m., June 4	OBS	10.26		9.03		8.45		5.46		9.17	
		BASE	8.45	-17.63	7.54	-16.53	3.78	-55.27	1.03	-81.14	13.50	47.27
		OPT	11.54	12.50	10.92	20.89	7.30	-13.61	1.75	-67.96	13.90	51.64
	From 10 a.m., June 9 to 10 a.m., June 11	OBS	17.68		8.54		15.26		3.71		4.76	
		BASE	11.06	-37.45	4.98	-41.72	13.45	-11.88	1.35	-63.59	2.01	-57.77
		OPT	17.37	-1.76	10.39	21.60	18.74	22.78	1.75	-52.80	3.32	-30.25
	From 10 a.m., June 16 to 10 a.m., June 18	OBS	8.62		21.87		14.95		10.14		9.74	
		BASE	3.84	-55.47	20.06	-8.29	14.20	-4.99	5.97	-41.11	8.70	-10.65
		OPT	10.43	20.94	28.78	31.57	17.64	18.03	6.78	-33.12	8.40	-13.73
OC	From 10 a.m., June 9 to 10 a.m., June 11	OBS	19.80		19.54		18.95		15.70		29.15	
		BASE	10.15	-48.74	10.30	-47.30	10.65	-43.81	6.12	-61.02	15.07	-48.30
		OPT	18.50	-6.57	15.50	-20.70	13.50	-28.77	8.12	-48.28	15.95	-45.28

**Table S6. The NMB and R values between observed and simulated surface chemical species over CEC in the BASE and OPT cases.**

Provinces	BASE case (NMB % /R)					OPT case (NMB % /R)				
	CO	SO <sub>2</sub>	NO <sub>2</sub>	PM <sub>2.5</sub>	PM <sub>10</sub>	CO	SO <sub>2</sub>	NO <sub>2</sub>	PM <sub>2.5</sub>	PM <sub>10</sub>
<b>Henan</b>	-22.34/0.75	-29.05/0.69	-5.33/0.71	-24.73/0.74	-20.89/0.78	-12.25/0.89	-22.23/0.79	3.02/0.78	-1.28/0.90	-2.03/0.89
<b>Anhui</b>	-20.67/0.71	-28.02/0.71	-7.56/0.69	-19.32/0.70	-22.49/0.72	5.19/0.88	-26.85/0.81	-99.97/0.79	4.18/0.80	6.11/0.84
<b>Hubei</b>	-29.53/0.41	-30.35/0.42	-18.55/0.33	-32.97/0.31	-31.83/0.41	-13.61/0.62	-22.09/0.61	-12.59/0.42	-2.23/0.53	-3.06/0.61
<b>Hunan</b>	-11.99/0.63	-15.73/0.62	-17.01/0.66	-10.56/0.66	-15.62/0.69	9.08/0.81	-19.06/0.77	-17.13/0.76	8.21/0.74	6.23/0.79
<b>Jiangxi</b>	-14.86/0.65	-19.54/0.59	-17.96/0.61	-7.15/0.59	-12.63/0.61	6.39/0.71	-20.05/0.68	-19.98/0.78	5.22/0.56	7.16/0.62
<b>Zhejiang</b>	-17.03/0.79	-17.63/0.75	17.36/0.77	-5.23/0.81	-11.53/0.77	4.22/0.86	-19.35/0.79	19.08/0.86	3.45/0.80	3.45/0.85
<b>Fujian</b>	-29.63/0.74	-36.49/0.66	-36.86/0.69	-39.00/0.67	-24.51/0.77	-11.06/0.68	-36.52/0.75	-28.59/0.81	-22.00/0.64	-16.03/0.77
<b>Shandong</b>	-26.33/0.77	-33.15/0.57	-16.39/0.67	-28.51/0.84	-27.61/0.81	-15.04/0.80	-33.89/0.69	-17.16/0.70	-17.89/0.82	-12.09/0.86
<b>Jiangsu</b>	-28.03/0.73	-38.22/0.48	-27.43/0.60	-37.08/0.85	-33.49/0.83	-13.23/0.79	-38.00/0.77	-25.51/0.66	-29.17/0.79	-11.92/0.88
<b>Shanghai</b>	-24.49/0.81	-30.15/0.52	-6.07/0.63	-38.05/0.79	-30.09/0.73	-11.01/0.87	-26.85/0.81	-5.08/0.67	-13.63/0.81	-9.16/0.79



80 **Table S7. The NMB and R values between observed and simulated surface meteorological species over CEC in the OPT case.**

Provinces	OPT case (NMB %/R)			
	Temperature	Relative humidity	Wind speed	PBL height
<b>Henan</b>	-0.03/0.87	-0.05/0.71	0.19/0.61	-2.13/0.63
<b>Anhui</b>	0.06/0.72	-0.21/0.55	0.08/0.41	3.18/0.66
<b>Hubei</b>	-0.04/0.85	0.31/0.72	0.48/0.49	2.19/0.71
<b>Hunan</b>	-0.11/0.79	-0.24/0.67	0.96/0.49	3.49/0.51
<b>Jiangxi</b>	-0.28/0.80	-0.12/0.64	0.60/0.52	2.96/0.55
<b>Zhejiang</b>	-0.12/0.83	-0.12/0.72	0.90/0.38	-3.05/0.48
<b>Fujian</b>	-0.33/0.84	-0.36/0.66	0.75/0.52	4.96/0.67
<b>Shandong</b>	-0.36/0.81	-0.42/0.63	0.66/0.62	3.59/0.41
<b>Jiangsu</b>	-0.29/0.74	-0.41/0.64	0.86/0.55	4.03/0.62
<b>Shanghai</b>	-0.39/0.69	-0.45/0.59	0.94/0.71	4.11/0.59