Supplement

Tables

Table S1. The information of each city over BTH and YRD regions in this study. TaizhouJS denotes Taizhou City in Jiangsu Province, while TaizhouZJ refers to Taizhou City in Zhejiang Province. The altitude data represent the average elevation of the urban areas, with population and area statistics sourced from the Ministry of Civil Affairs of the People's Republic of China

Name	Latitude	Longitude	Altitude (m)	Number of site	Population（million）	Area（thousand km2）
Beijing	40.0° N	116.4° E	455	12	13.92	1.6
Tianjin	39.1	117.3	64	15	11.05	1.2
Baoding	38.9	115.5	338	6	10.9	2.2
Tangshan	39.6	118.1	90	6	7.56	1.3
Langfang	39.5	116.7	45	4	4.83	0.6
Shijiazhuang	38.0	114.5	337	8	9.89	1.4
Qinhuangdao	39.5	119.6	143	5	3.01	0.8
Zhangjiakou	40.8	114.9	1203	5	4.65	3.6
Chengde	41.0	117.9	829	5	3.83	4.0
Cangzhou	38.3	116.9	11	3	7.87	1.3
Hengshui	37.7	115.7	27	3	4.58	0.9
Xingtai	37.1	114.5	356	4	8.01	1.2
Handan	36.6	114.5	310	4	10.61	1.2
Shanghai	31.2	121.5	13	10	14.69	0.6
Nanjing	32.1	118.8	28	9	7.1	0.7
Wuxi	31.6	120.3	8	8	5.03	0.5
Changzhou	31.8	120.0	5.3	6	3.85	0.4
Suzhou	32.1	119.4	6	8	7.23	0.8
Nantong	32.0	120.9	3	5	7.6	0.8
Yancheng	33.4	120.2	3	4	8.21	1.7
Yangzhou	32.4	119.4	10	4	4.57	0.7
Zhenjiang	32.2	119.5	20	4	2.7	0.4
TaizhouJS	32.4	120.0	7	4	5.01	0.6
Hangzhou	30.2	120.1	186	11	7.59	1.7
Ningbo	29.9	121.6	37	8	6.08	0.9
Wenzhou	28.0	120.7	217	4	8.32	1.2
Jiaxing	30.7	120.7	5	3	3.64	0.4
Huzhou	30.9	120.1	65	3	2.68	0.6
Shaoxing	30.0	120.6	180	3	4.48	0.8
Jinhua	29.1	119.7	316	3	4.92	1.1
Zhoushan	30.0	122.2	10	3	0.97	0.1
TaizhouZJ	28.6	121.4	141	3	6.07	0.9
Hefei	31.8	117.2	71	10	7.7	1.1
Wuhu	31.4	118.4	57	4	3.9	0.6
Maanshan	31.7	118.5	23	5	2.29	0.4

Tongling	30.9	117.8	100	6	1.71	0.3
Anqing	30.5	117.0	210	4	5.92	1.4
Chuzhou	32.3	118.3	36	3	4.55	1.3
Chizhou	30.7	117.5	216	3	1.62	0.8
Xuancheng	31.0	118.7	226	3	2.79	1.2

Table S2. The input variables for LightGBM model in this study.

	Type	Abbreviation	Description	Source
Features	/	date	Year, month, day and hour	/
		hour	Values from 0 to 23	
		lon	longitude	
		lat	latitude	
	observation	CO NO_2 SO_2 O_3	Average observation data per hour of near-surface observation	CNEMC
	meteorogloy	CLDTOT	Total Cloud Cover	0.25° × 0.3125°GEOS FP
		PRECTOT	Total Precipitation	
		QV2M	Specific Humidity at 2 Meters	
		T2M	Temperature at 2 Meters	
		SLP	Sea Level Pressure	
		SWGDN	Downward Shortwave Radiation	
		U10M	10 Meter U-Wind Component	
		V10M	10 Meter V-Wind Component	
	emission	CO2_agr,CH2O_agr,CO_agr, NH3_agr,NO_agr,BC_agr, SO2_agr,OC_agr,PRPE_agr CO2_ind,CH2O_ind,CO_ind , NH3_ind,NO_ind, BC_ind, SO2_ind, OC_ind,PRPE_ind CO2_tra, CH2O_tra, CO_tra, NH3_tra,NO_tra, BC_tra, SO2_tra, OC_tra, PRPE_tra CO2_rco, CH2O_rco,CO_rco, NH3_rco, NO_rco, BC_rco, SO2_rco, OC_rco, PRPE_rco CO2_wst,CH2O_wst,CO_wst, NH3_wst, NO_wst, BC_wst, SO2_wst, OC_wst, PRPE_wst CO2_shp,CH2O_shp,CO_shp, NH3_shp, NO_shp, BC_shp, SO2_shp, OC_shp, PRPE_shp CO2_slv, CH2O_slv, CO_slv,	Anthropogenic emissions of CO2, CH2O, CO, NH3, NO, BC, SO2, OC, PRPE from the following eight sectors [Non-combustion agricultural sector, Energy transformation and extraction, Industrial combustion and processes, Surface Transportation, (Residential, commercial, and	CEDS

		NH3_slv, NO_slv, BC_slv, SO2_slv, OC_slv, PRPE_slv CO2_ene,CH2O_ene,CO_ene, NH3_ene, NO_ene, BC_ene, SO2_ene, OC_ene, PRPE_ene	other), Solvents, Waste disposal and handling, International shipping]	
Target	observation	$PM_{2.5}$ PM_{10}	Average observation data per hour of near-surface observation	CNEMC

Table S3. The performance of LightGBM model of $PM_{2.5}$ and PM_{10}, respectively. TaizhouJS denotes Taizhou City in Jiangsu Province, while TaizhouZJ refers to Taizhou City in Zhejiang Province.

City	$PM_{2.5}$/PM_{10}	R	RMSE	MAE
Beijing	$PM_{2.5}$	0.9456	19.5576	11.0172
	PM_{10}	0.8946	35.5833	18.0161
Tianjin	$PM_{2.5}$	0.9203	20.2009	13.1755
	PM_{10}	0.8351	39.4376	21.6897
Baoding	$PM_{2.5}$	0.9567	22.9806	13.3205
	PM_{10}	0.9192	42.9188	22.4972
Tangshan	$PM_{2.5}$	0.9421	19.1396	12.5095
	PM_{10}	0.8647	44.1919	23.8677
Langfang	$PM_{2.5}$	0.9627	16.8245	10.0948
	PM_{10}	0.9101	36.8173	19.6753
Shijiazhuang	$PM_{2.5}$	0.9592	20.3096	13.2612
	PM_{10}	0.9170	40.6463	23.0981
Qinhuangdao	$PM_{2.5}$	0.9302	14.9428	9.5907
	PM_{10}	0.8774	30.5758	17.6527
Zhangjiakou	$PM_{2.5}$	0.8771	12.5324	7.9124
	PM_{10}	0.7631	61.1773	25.5808
Chengde	$PM_{2.5}$	0.9186	12.2018	7.3763
	PM_{10}	0.8408	36.8077	19.0527
Cangzhou	$PM_{2.5}$	0.9433	17.6925	11.4718
	PM_{10}	0.8684	39.4473	20.3909
Hengshui	$PM_{2.5}$	0.9316	23.7654	14.8763
	PM_{10}	0.8813	46.7182	29.1470
Xingtai	$PM_{2.5}$	0.9495	22.3215	15.1406
	PM_{10}	0.9225	39.1189	25.1575
Handan	$PM_{2.5}$	0.9365	23.6699	15.2945
	PM_{10}	0.9113	41.0271	25.3900
Shanghai	$PM_{2.5}$	0.9314	11.6748	8.1831
	PM_{10}	0.8863	18.6757	11.2518
Nanjing	$PM_{2.5}$	0.9362	12.6073	8.1863
	PM_{10}	0.9064	23.1176	13.9726
Wuxi	$PM_{2.5}$	0.9487	10.4380	7.2177
	PM_{10}	0.9220	18.6968	11.3457
Changzhou	$PM_{2.5}$	0.9239	12.7242	7.7121
	PM_{10}	0.9109	20.5882	12.3071
Suzhou	$PM_{2.5}$	0.9215	13.0630	9.1440
	PM_{10}	0.8713	22.3178	13.8686
Nantong	$PM_{2.5}$	0.9236	13.3771	9.2351
	PM_{10}	0.8962	20.9028	13.5661
Yancheng	$PM_{2.5}$	0.9379	12.0557	8.07435
	PM_{10}	0.8818	23.3246	14.5720
Yangzhou	$PM_{2.5}$	0.9080	14.6791	9.8450

Zhenjiang	PM_{10}	0.8865	25.3254	16.5752
	$PM_{2.5}$	0.8728	17.9496	12.0374
TaizhouJS	PM_{10}	0.8612	25.9416	17.6306
	$PM_{2.5}$	0.9410	13.0533	8.9153
Hangzhou	PM_{10}	0.9075	24.2238	15.4136
	$PM_{2.5}$	0.9633	7.8875	5.1830
Ningbo	PM_{10}	0.9490	13.7075	8.8852
	$PM_{2.5}$	0.9733	6.3306	4.1017
Wenzhou	PM_{10}	0.9598	11.1911	6.9350
	$PM_{2.5}$	0.9410	7.3963	5.0486
Jiaxing	PM_{10}	0.9367	12.3741	8.5291
	$PM_{2.5}$	0.9440	10.0331	6.6220
Huzhou	PM_{10}	0.9372	14.6223	9.6662
	$PM_{2.5}$	0.8517	14.6820	8.9670
Shaoxing	PM_{10}	0.8872	16.0286	10.4537
	$PM_{2.5}$	0.9223	10.9524	7.8899
Jinhua	PM_{10}	0.9081	19.6061	13.3585
	$PM_{2.5}$	0.9230	10.7899	7.2881
Zhoushan	PM_{10}	0.9243	14.4384	9.8878
	$PM_{2.5}$	0.9397	6.8332	4.4021
TaizhouZJ	PM_{10}	0.9120	12.4702	7.7865
	$PM_{2.5}$	0.9340	8.2043	5.2772
Hefei	PM_{10}	0.9310	12.6660	8.2562
	$PM_{2.5}$	0.9040	15.7513	10.5492
Wuhu	PM_{10}	0.8607	25.6868	16.9748
	$PM_{2.5}$	0.9031	14.6972	9.8951
Maanshan	PM_{10}	0.8973	20.1732	13.4575
	$PM_{2.5}$	0.9144	14.2384	9.4707
Tongling	PM_{10}	0.8928	21.0516	13.5703
	$PM_{2.5}$	0.9446	11.5669	8.1408
Anqing	PM_{10}	0.9395	15.7447	11.3612
	$PM_{2.5}$	0.9251	13.3497	9.0131
Chuzhou	PM_{10}	0.9084	18.4351	12.8011
	$PM_{2.5}$	0.9320	13.0864	9.2711
Chizhou	PM_{10}	0.9038	20.9232	14.5182
	$PM_{2.5}$	0.9411	11.8886	8.3402
Xuancheng	PM_{10}	0.9331	17.4935	12.5070
	$PM_{2.5}$	0.8926	14.6758	10.0272
	PM_{10}	0.8715	19.8953	14.2165

Figures

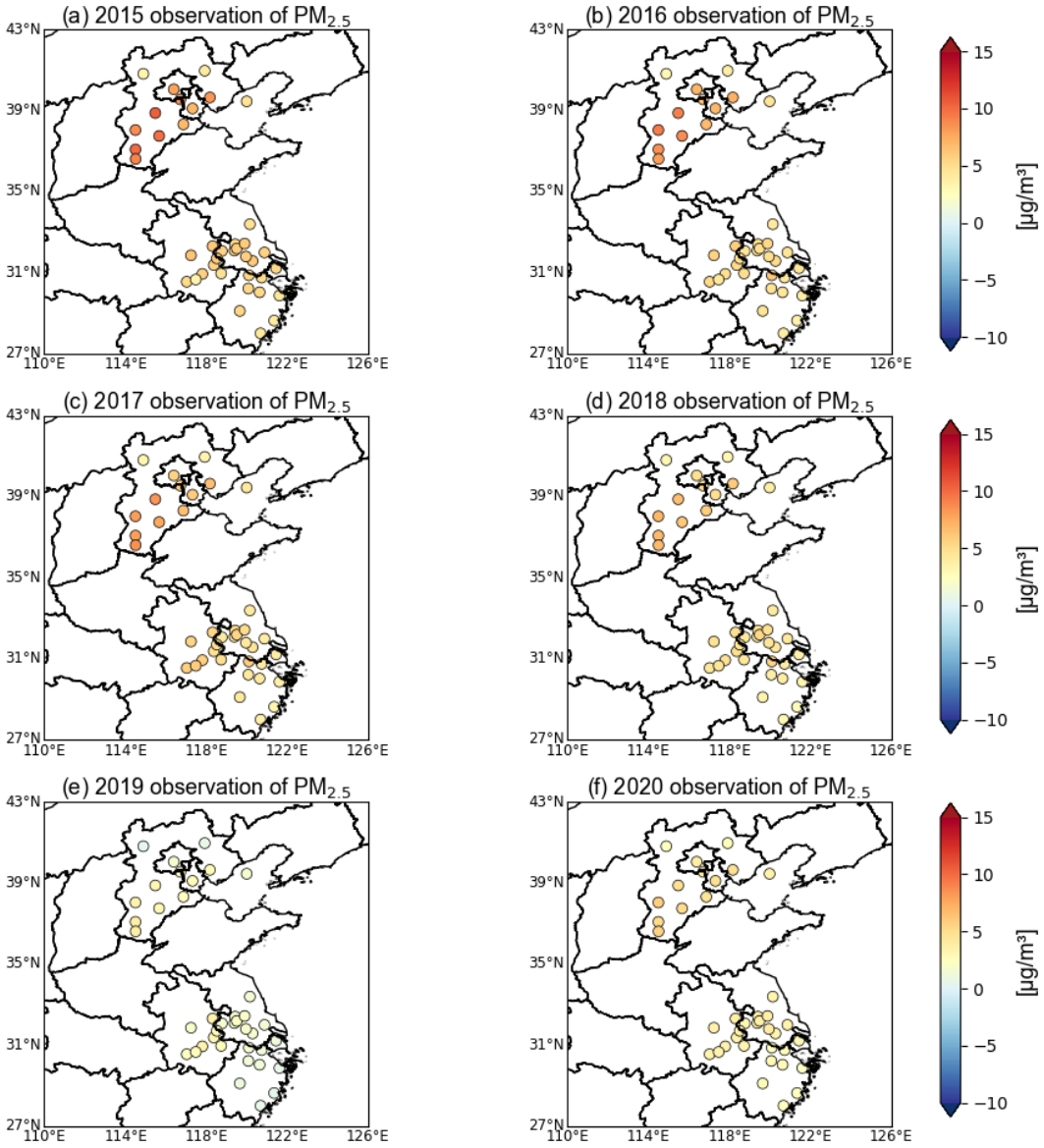

Fig. S1. The average concentrations of $PM_{2.5}$ over BTH and YRD regions during 2015 to 2020.

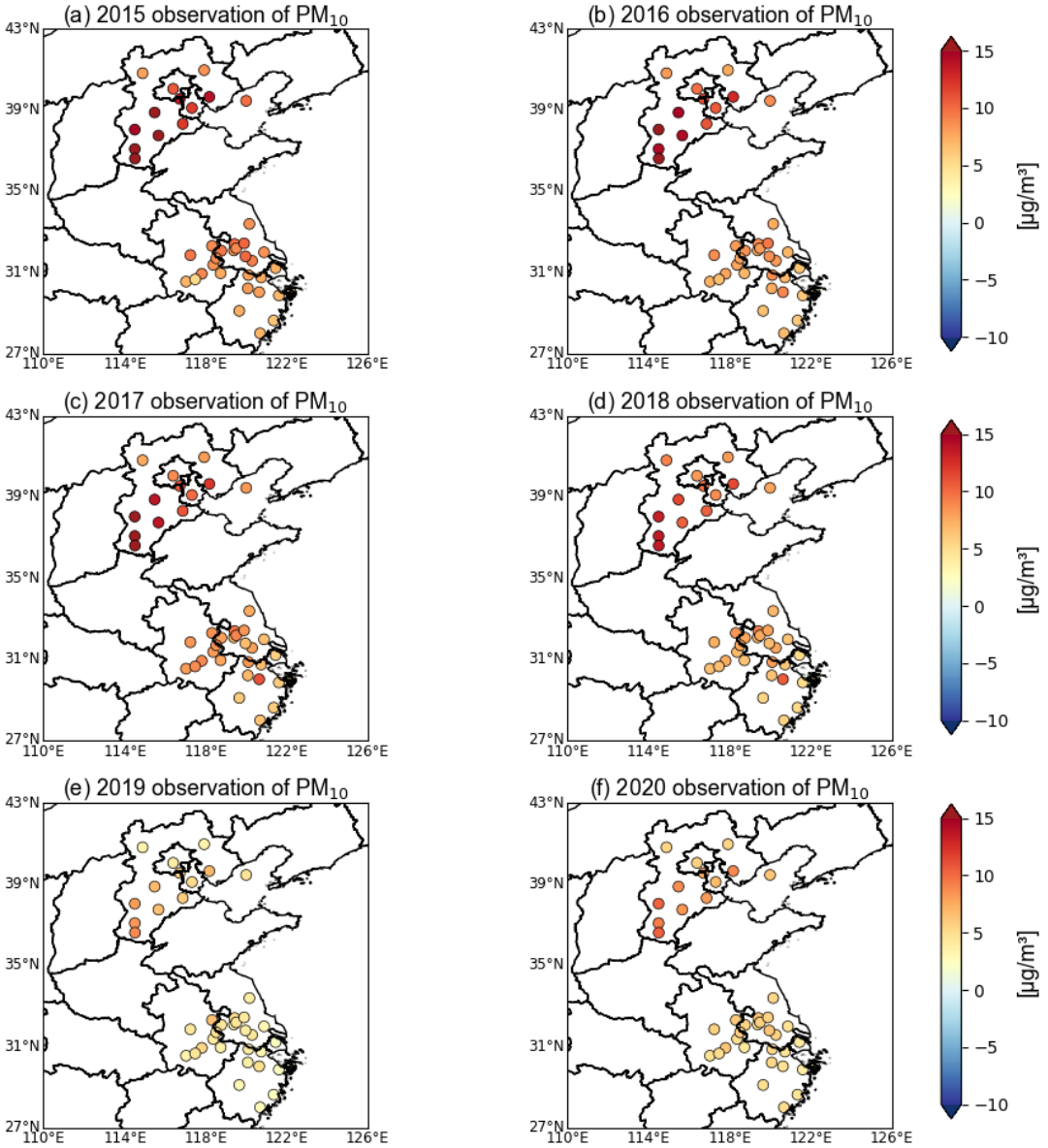

Fig. S2. The average concentrations of PM_{10} over BTH and YRD regions during 2015 to 2020.

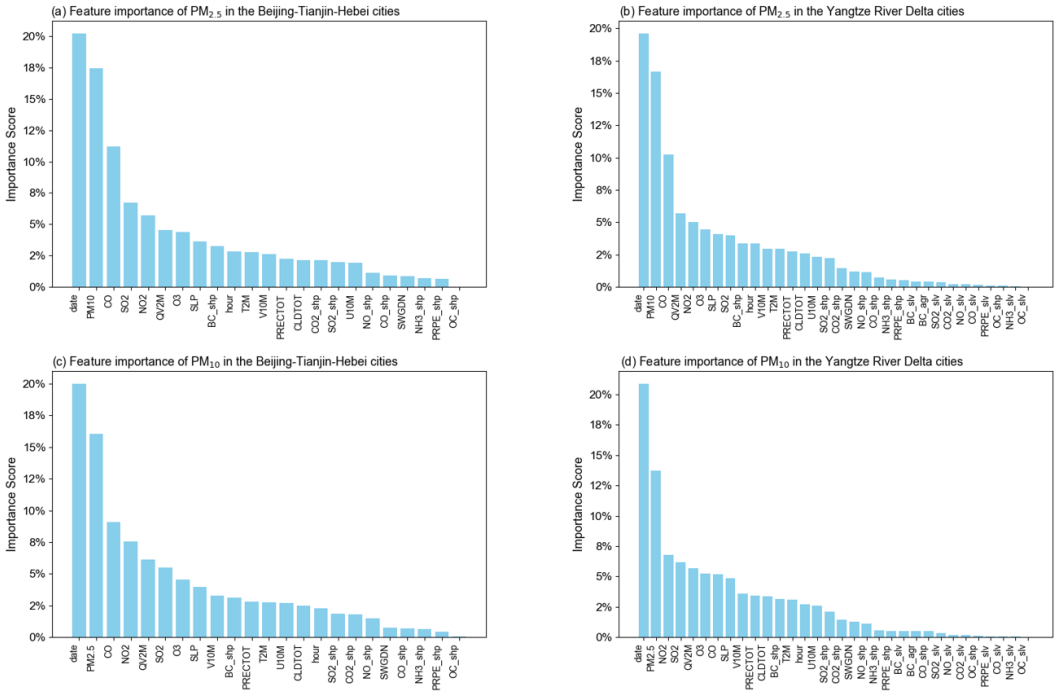

Fig. S2. The feature importance of $PM_{2.5}$ and PM_{10} over BTH and YRD regions.

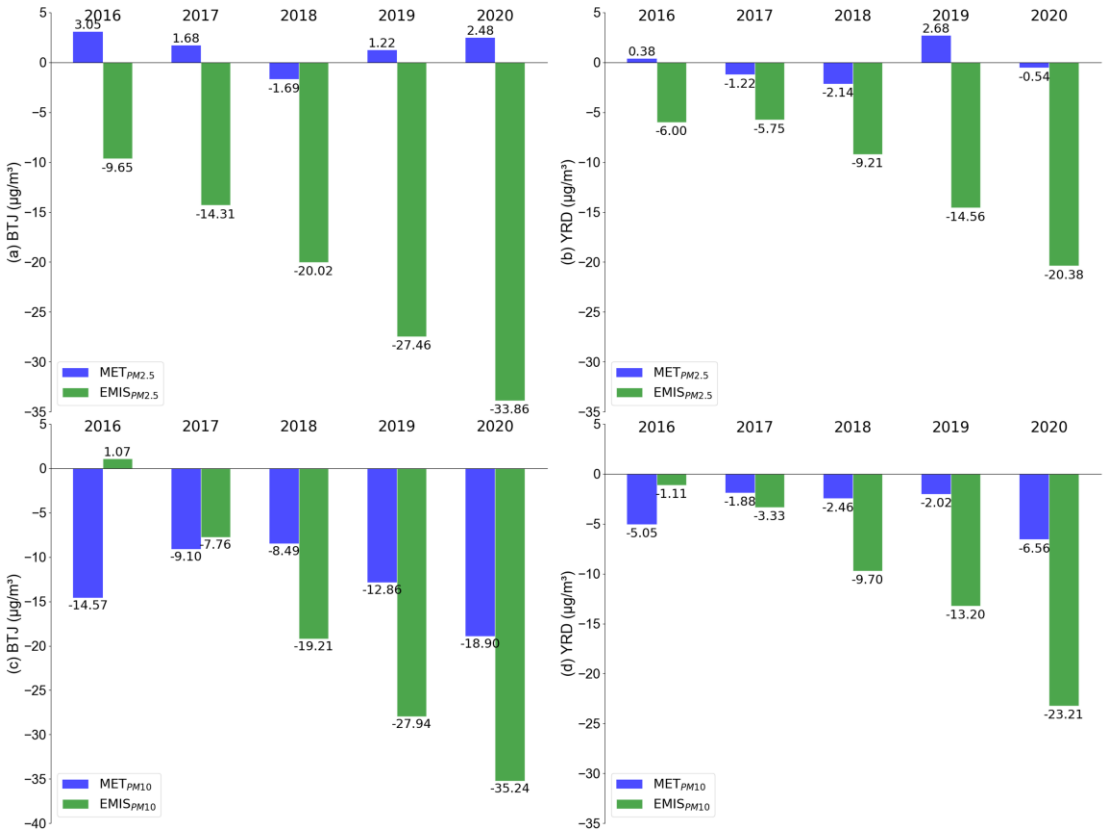

Fig. S3. The averaging the emission or meteorological contributions to $PM_{2.5}$ and PM_{10} of each year relative to 2015 over BTH and YRD, respectively.

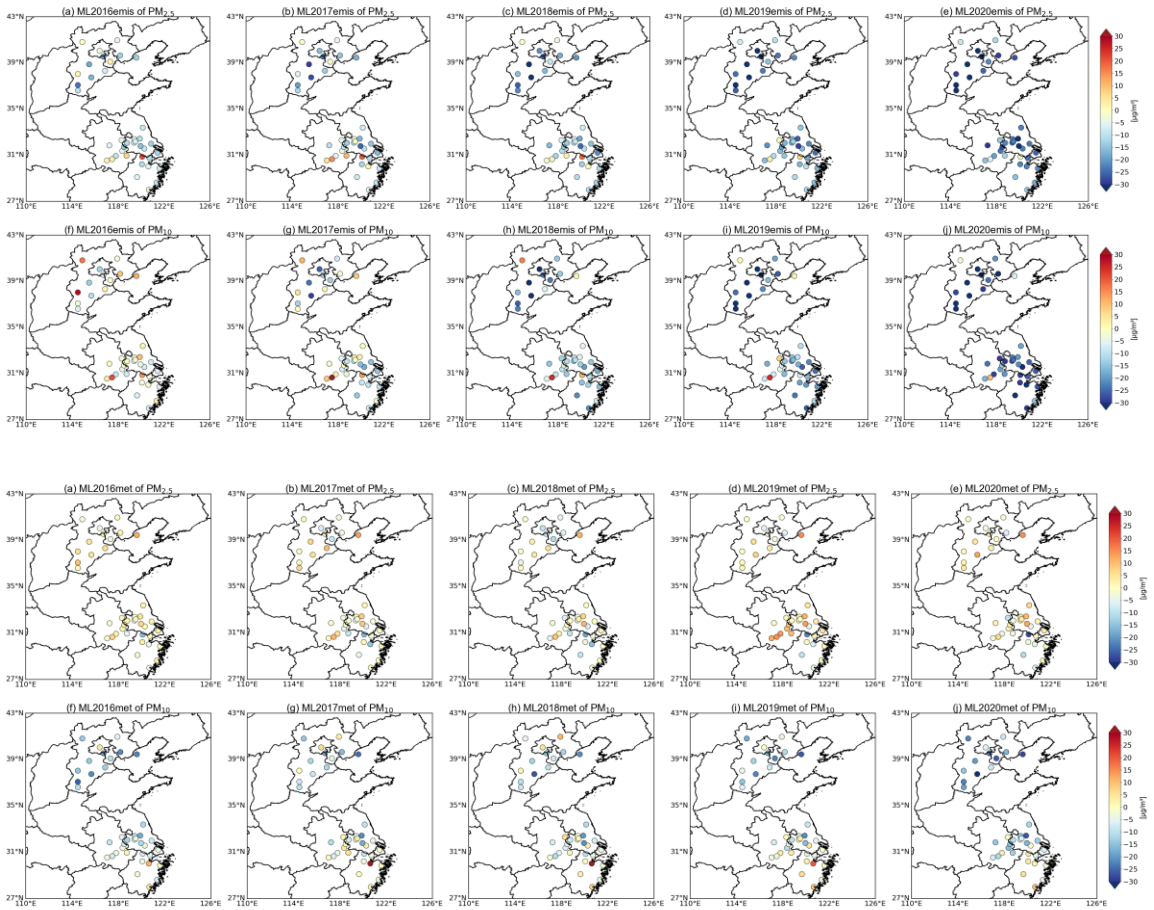

Fig. S4. The spatial distribution of averaging the emission or meteorological contributions to $PM_{2.5}$ and PM_{10} of each year relative to 2015 over BTH and YRD during 2015 to 2020.

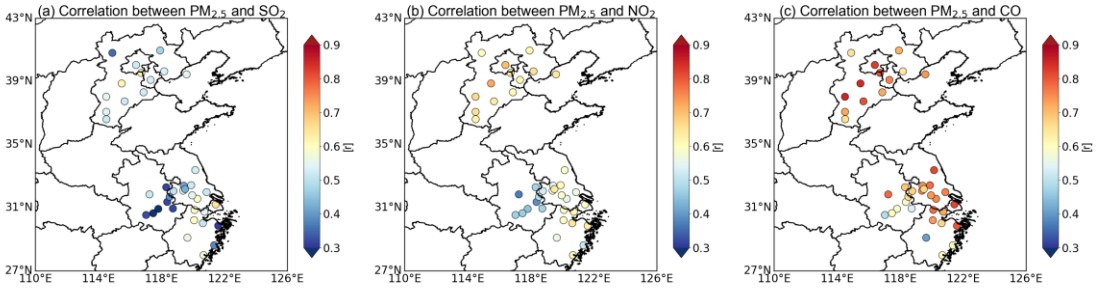

Fig. S5. The correlations among $PM_{2.5}$, SO_2, NO_2, and CO for each city over BTH and YRD regions during 2015 to 2020.

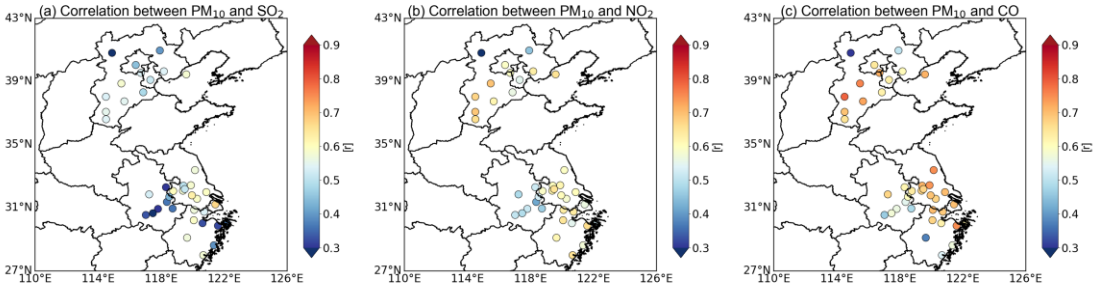

Fig. S6. The correlations among PM_{10}, SO_2, NO_2, and CO for each city over BTH and YRD regions during 2015 to 2020.