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Air quality and health benefits from ultra-low emission control policy indicated by continuous emission monitoring: a case study in the Yangtze River Delta region, China

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Table S1 Evaluation of WRF simulation performance of meteorological parameters in D2.

Parameters		Jan	Apr	Jul	Oct	Benchmark
Wind speed (WS10)	Obs (m/s)	2.69	2.99	2.75	2.43	
	Sim (m/s)	2.80	3.11	2.67	2.52	
	Bias (m/s)	0.12	0.11	-0.08	0.09	
	RMSE (m/s)	0.39	0.43	0.34	0.33	≤ 2.0
	IOA	0.94	0.95	0.97	0.95	≥ 0.6
Wind direction (WD10)	Obs (°)	183.05	177.54	163.67	174.14	
	Sim (°)	161.16	153.44	147.07	145.58	
	Bias (°)	-21.90	-23.32	-16.60	-28.56	≤ 10
Temperature (T2)	Obs (°C)	4.86	15.49	26.21	18.11	
	Sim (°C)	4.96	15.12	25.59	18.22	
	Bias (°C)	0.10	-0.35	-0.62	0.12	≤ 0.5
	RMSE (°C)	0.70	1.06	1.13	0.63	
	IOA	0.99	0.99	0.97	0.99	≥ 0.7
Relative Humidity (RH2)	Obs (%)	66.58	71.04	81.32	71.81	
	Sim (%)	72.93	77.64	82.16	68.61	
	Bias (%)	6.35	6.60	0.84	-3.20	
	RMSE (%)	13.26	10.36	3.55	6.48	
	IOA	0.85	0.89	0.97	0.96	≥ 0.7

Note: The benchmarks of statistical indicators for the meteorological parameters were reported in (Emery, C., Tai, E., and Yarwood, G.: Enhanced meteorological modeling and performance evaluation for two Texas episodes, Report to the Texas Natural Resources Conservation Commission, prepared by ENVIRON, International Corp, Novato, CA, 2001). The Bias, IOA and RMSE were calculated using the following equations (P, O and $\overline{O}$ represent the simulation, observation, and averaged observation value, respectively):

$$Bias = \frac{1}{n}\sum_{i=1}^{n}(P_i - O_i); \quad IOA = 1 - \frac{\sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(|P_i - \overline{O}_i| + |O_i - \overline{O}_i|)^2}; \quad RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)^2}$$

Table S2 The ultra-low emission standard limits by sector (mg/m^3).

Sector	Section	Pollutants	Ultra-low emission limits	References
Power	Coal-fired	SO_2	35	MEP et al. (2015)
		NO_X	50	
		PM	10	
Iron & steel	Sintering	SO_2	35	MEE (2019)
		NO_X	50	
		PM	10	
Iron & steel	Iron making	SO_2	50	MEE (2019)
		NO_X	150	
		PM	10	
Cement	Cement	SO_2	30	HBDEE and HBAMR (2020)
		NO_X	50	
		PM	10	
Industrial boiler	Coal-fired	SO_2	50	SDDEE and SDBQTS (2018)
		NO_X	100	
		PM	10	

Note: The details for the references:

Hebei Department of Ecology and Environment (HBDEE), Hebei Administration for Market Regulation (HBAMR). Ultra-low Emission Standard of Air Pollutants for Cement Industry, DB13/2167-2020. 2020, Hebei, China.

Ministry of Ecology and Environment of the People's Republic of China (MEE), Opinions on Promoting the Implementation of Ultra-low Emissions in the Steel Industry, 2019, Beijing, China.

Ministry of Environmental Protection of the People's Republic of China (MEP), National Development and Reform Commission (NDRC), National Energy Administration (NEA). Work Plan for Fully Implementing Ultra-low Emissions and Energy Conservation in Coal-Fired Power Plants, 2015, Beijing, China.

Shandong Department of Ecology and Environment (SDDEE), Shandong Bureau of Quality and Technical Supervision (SDBQTS). Emission Standard of Air Pollutants for Boilers, DB37/2374-2018. 2018, Shandong, China.

Table S3 The fractions of males and females by region in the YRD for 2015.

Province or city	Male	Female
Anhui	0.51	0.49
Shanghai	0.50	0.50
Jiangsu	0.50	0.50
Zhejiang	0.51	0.49

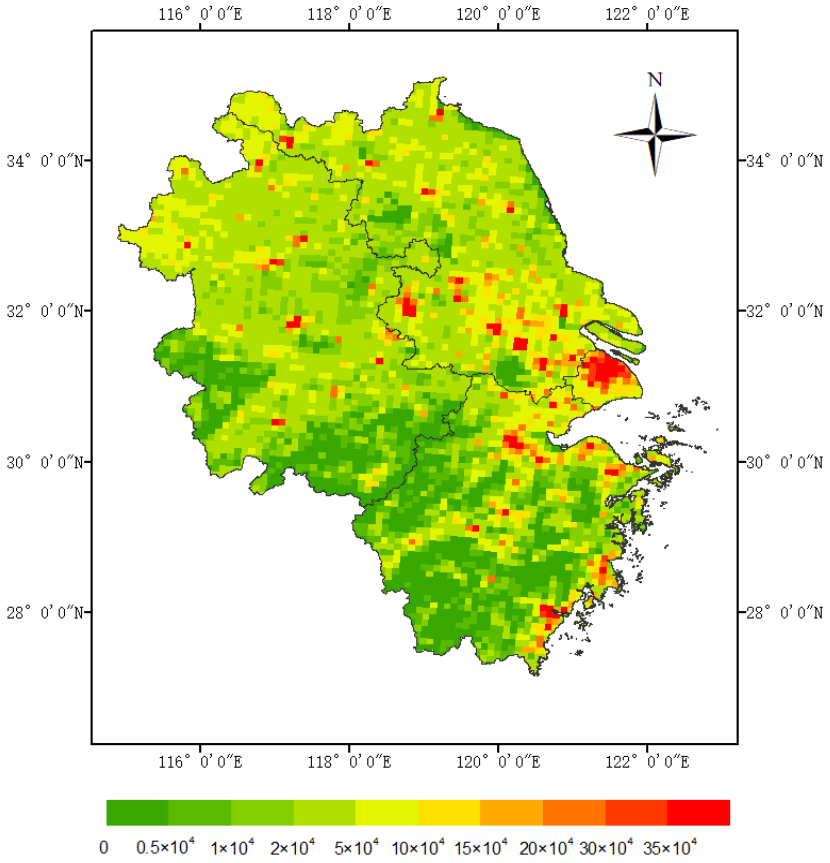
Table S4 The baseline mortalities (y_0, cases/10^5) by age group in China. Note LRI is a common disease among young children, and its baseline mortalities are 13.7 and 11.4 cases/10^5 for male and female regardless of age, respectively.

Age (year)	IHD		STK		COPD		LC	
	Male	Female	Male	Female	Male	Female	Male	Female
25-29	5.9	2.1	4.9	1.8	0.7	0.4	1.1	0.6
30-34	9.7	3.1	7.8	2.9	1	0.7	2.5	1.3
35-39	15.3	5	13.6	5.8	1.8	1.1	4.7	2.9
40-44	26.7	9.2	27.3	13.2	3.8	2.3	10.9	6.1
45-49	45.2	16.4	52.2	27	7.5	4.1	25.4	11.4
50-54	77.5	29.7	100.3	52.8	17.5	8.9	55.4	21.7
55-59	125.8	50.2	176.6	89.2	39.3	18.6	102.9	35.4
60-64	215.1	99	326.5	165.4	97.8	46.2	180.3	57.1
65-69	372.6	182.9	571.1	300.5	221.6	105.2	270.5	83.1
70-74	615	364	996.8	553.3	494.7	238.5	381.2	126.3
75-79	1050.4	676.3	1648.7	993.2	910.6	475.1	495.2	175.5
80+	2865.5	2551.6	3551.5	3037.6	2459	1782.1	622	268.7

Table S5 The life expectancy by age group in China.

Age (year)	Male	Female
<1	74.8	77.7
1-4	74.5	77.4
5-9	70.6	73.5
10-14	65.7	68.6
15-19	60.8	63.7
20-24	55.9	58.8
25-29	51.1	53.9
30-34	46.2	49.0
35-39	41.5	44.2
40-44	36.7	39.4
45-49	32.0	34.6
50-54	27.3	29.9
55-59	22.9	25.3
60-64	18.6	20.9
65-69	14.8	16.8
70-74	11.4	13.2
75-79	8.7	10.0
80-84	6.7	7.5
85-89	4.9	5.5
90-94	3.7	4.2
95-99	2.9	3.2
100+	2.4	2.8

Figure S1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28° 0′ 0″N
0
0.5×10^4
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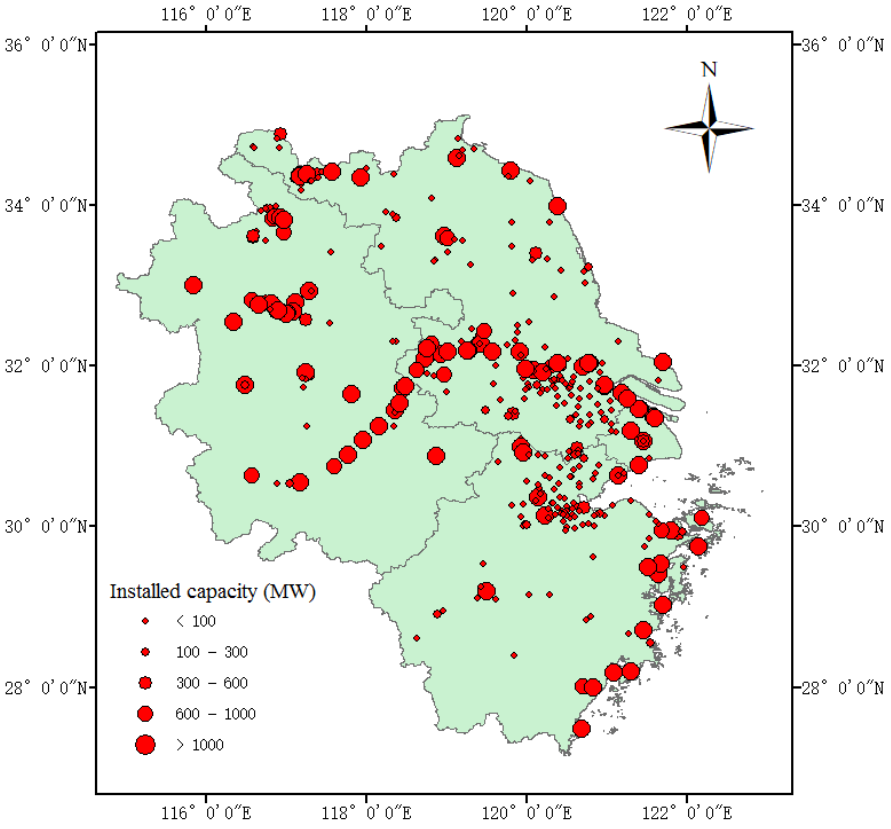
Figure S2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34° 0′ 0″N
32° 0′ 0″N
30° 0′ 0″N
28° 0′ 0″N
N
Installed capacity (MW)
< 100
100 – 300
300 – 600
600 – 1000
> 1000