Supplement of

Emission inventory of air pollutants and chemical speciation for detailed anthropogenic sources based on local measurements in the Yangtze River Delta region, China

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1. Sources classification

Table S1 shows the source classification in different levels in the Yangtze River Delta (YRD) region. In the first level, the sources are classified into ten categories, including stationary combustion source, industrial process source, industrial solvent-use source, mobile source, dust source, oil storage and transportation source, residential source, waste treatment and disposal source, and agricultural source. The second-level categories of stationary combustion source include power plants and boilers. The three-level classification is based on fuel type, which mainly includes coal, natural gas, fuel oil, diesel, and biomass, etc. The fourth level is classified according to the combustion method, such as grate-fired boilers, pulverized coal boilers, and fluidized bed combustion (FBC) boilers, etc. Industrial process and solvent-use sources are divided into second- and third-level according to their industrial sectors and product or material types. Some sources are further subdivided into the fourth-level based on their detailed product types or emission segments. For example, in the coating production industry, solvent- and water-based coatings are further separated. In the ironmaking industry, organized emission segments including sintering and blast furnaces, and fugitive emission segments are further separated. The second-level classification of mobile source includes motor vehicles, ships, non-road machinery, and civil aviation aircraft. The third-level is divided according to their detailed types. Motor vehicles include light-duty passenger cars, light-duty trucks, heavy-duty passenger vehicles, heavy-duty trucks, and motorcycles, etc. Non-road machinery is divided into construction machinery, port machinery, factory machinery, agricultural machinery, and airport ground handling equipment (GHE) according to their purpose. The fourth-level classification mainly considers their fuel type. The motor vehicles and non-road machinery are further classified into the fifth-level according to their emission levels. The dust source is mainly divided into two categories: construction dust and road dust. The oil storage and transportation sources mainly include oil and gas volatilization sources such as gas stations, storage tanks and loading and unloading operations. The

residential source includes residential combustion, residential solvent-use, catering, and human excretion. The residential solvent-use source is further divided into architectural coatings, consumer products, auto repair, dry cleaning, and hospital solvent-use. The waste treatment and disposal sources include sewage treatment and waste treatment. The waste treatment source is further divided into landfill and compost, while the incineration is included in the boiler source. The agricultural source includes livestock and poultry breeding, N-fertilizer application, and biomass burning. The livestock and poultry breeding and biomass burning sources are further divided into the third-level based on the species of livestock and poultry and crop residue types, respectively. Biomass burning includes two categories of field burning and household stoves, and then the fourth level according to different straw types, such as soybean, rape, rice, wheat, corn, etc.

2. Activity data sources

Table S2 shows the emission estimation methods and activity data sources for various sources and their reliability levels. The activity data for stationary combustion source, industrial process source and industrial solvent-use source are mainly derived from 2017 environmental statistics, covering nearly 30,000 major point sources in the YRD region. The data used in this study mainly includes fuel consumption, sulfur and ash content, product output, raw material consumption, solvent usage, and pollutant removal method and its efficiency, etc. However, the environmental statistics cannot include all industrial sources. The difference between the total fuel consumption and product output in the statistical yearbook and the sum of environmental statistics for each city is taken as an area source.

For motor vehicles, the number of various vehicle types come from the statistical yearbook of each city. To prepare the fleet composition data, detailed information about vehicle technology, fuel type, emission standard, and vehicle age was surveyed in the representative cities like Nanjing, Hangzhou, and Shanghai. The annual average VMT of each vehicle type is simultaneously obtained from local survey in these cities. The

total VMT is then allocated into four road types, including highways, elevated roads, arterial roads, and residential roads, based on their traffic flows and road length. The average speeds and driving cycles for different road types were obtained from previous studies (Huang et al., 2015; Tang et al., 2018). Since there are no ready-made statistics for other machines besides agricultural machinery, the numbers of non-road machinery are calculated based on local survey data from Shanghai and Hangzhou. The number of construction machinery is calculated by the construction area; the number of port machinery is calculated according to the cargo throughput for each port; the number of factory machinery is estimated according to the total output value of the heavy industry; the number of GHE is estimated according to the passenger volume of the civil aviation. The working hours of various non-road machinery types come from local survey results in Shanghai and Hangzhou (Lu et al., 2017). The activity data of ships come from the AIS data for the East China Sea in 2017. The number of takeoffs and landings of civil aviation aircrafts at each airport are obtained based on the flight information survey on the Internet. The engine type for each aircraft can be determined based on the engine database released by ICAO.

The activity data of other sources is mainly from statistical yearbooks. The construction dust emissions are estimated based on the construction area of each city. The dust control measures during construction period are from the surveys of typical cities such as Hangzhou and Shanghai. The activity data of road dust is basically the same as that of motor vehicle emissions. NMVOC emissions from oil and gas storage and transportation sources are related with the transfer of oil products from various cities and the consumption of gas stations. All of the storage tanks and gas stations have been equipped with oil and gas recovery facilities. The activity data of residential combustion sources are derived from fuel statistics including coal, natural gas (NG), and liquefied petroleum gas (LPG), etc., used by residents of various cities. The activity data for architectural coatings is calculated based on the newly built and built-up housing area of each city, combined with the solvent consumption used per unit area

from survey. The activity data for catering, human excretion, consumer products, auto repair, and waste treatment and disposal sources are derived from statistics on population, vehicle ownership, and sewage and solid waste disposal. The activity data of agricultural sources comes from the statistics livestock and poultry farming in different species and nitrogen fertilizer application in each city. The activity data of Biomass burning is estimated based on the yield of different crops multiplied by the ratio of straw and then minus the recovery of straw.

3. Emission factors determination

Table S1 lists the emission factors (EFs) for various emission sources and their references. The EFs of coal-fired power plants mainly come from domestic measurement results (Liu, 2008; Yao et al., 2009; Zhao et al., 2010; Wang et al., 2011; Sun, 2015). The EFs of coal-fired boilers are determined by our local measurements in the YRD region (Lou, 2014; Xu et al., 2018). For other fuels and non-criteria pollutants (such as NMVOCs, NH_3, etc.), the EFs mainly refer to the USEPA's AP-42 (USEPA, 2002) and European's EMEP datasets (EEA, 2013). The EFs for industrial process sources are mainly derived from the datasets provided by AP-42, EMEP and domestic emission inventory (EI) guidebook of China (MEP, 2014). VOC content of coatings, inks and adhesives from industrial solvent-use sources are determined by local surveys in Shanghai and Hangzhou.

The EFs of motor vehicles are calculated by the International Vehicle Emissions (IVE) model and then corrected based on the local measurements of 102 light-duty gasoline vehicles (LDGVs) with Euro 2−5 standards and 33 heavy-duty diesel vehicles (HDDVs) with Euro 3−5 standards (Huang et al., 2016; Huang et al., 2017; Huang et al., 2018a; Huang et al., 2018b). The EFs for non-road machinery are referenced from the NONROAD model (USEPA, 2010) and domestic EI guidebook of China (MEP, 2014), and then corrected based on local measurements in previous studies in China (Fu et al., 2012; Fu et al., 2013; Ge et al., 2013; Qu et al., 2015; Li et al., 2016). The NO_x EFs from local measurements are generally higher than those recommended by the

model and guidebook, while other pollutants are relatively close. The EFs of ships are strongly related with the quality of fuel oils. China has executed the legislation that requires ships to use LSF (<0.5 wt% S) when at berth beginning from January 1, 2017. Therefore, the EFs were corrected based on the fuel quality in this study. Detailed information is provided in a previous study (Fan et al., 2016). The NO_x, CO, and NMVOC EFs of civil aircraft engines in each mode of operation are taken from the Aircraft Engine Emissions Database from ICAO (ICAO, 2014). The SO_2 and PM emissions are estimated using the mass balance and FOA3.0 methods, respectively.

The EFs of dust sources are mainly derived from the EI guidebook of China (MEP, 2014). Those of oil storage and transportation sources are determined from local surveys of the storage and transportation process of oil depots and gas stations. A total of 294 storage tanks for different oil types and more than 400 gas stations were surveyed in Shanghai and Hangzhou. Then the NMVOC EFs for per unit turnover for the storage and transportation process of oil depots and gas stations were determined based on the method recommended by USEPA (USEPA, 2015). Besides of the oil storage and transportation sources, the EFs of residential solvent-use sources, like architectural coatings, auto repair, dry cleaning, and hospital solvent-use, are also estimated based on the local surveys of typical sources in the YRD region. The EFs of catering and biomass burning are both determined based on the local measurements (Tang et al., 2014; Wang et al., 2018; Gao et al., 2019). For agricultural sources, the NH_3 emission factors of swine and dairy cow breeding, and fertilization in paddy and wheat fields are localized base on the measurements in Shanghai (Chen, 2017a; Chen et al., 2017b; Xia et al., 2018; Zhou, 2019). For the other area sources, the EFs are mainly referred to the EI guidebook of China (MEP, 2014).

4. $PM_{2.5}$ and NMVOC speciation

$PM_{2.5}$ and NMVOC speciation profiles of each source were determined based on local measurements in this and previous studies and the USEPA's SPECIATE4.4 database (Hsu et al., 2014). Table S3 shows the references, samples, and sampling and

analytical methods of different sources in this study. A total of 34 $PM_{2.5}$ sources and 64 NMVOC sources were localized in the YRD region. The speciation of $PM_{2.5}$ included carbonaceous, ionic, and elemental components, which were analyzed by a thermal/optical carbon analyzer (Model 2001, DRI, USA), an ion chromatography (Model 940, Metrohm, Switzerland), and an energy-dispersive X-ray fluorescence spectrometer (ED-XRF, Epsilon 5, PANalytical, Finland) or an inductively coupled plasma direct reading spectroscopy (ICP-AES, JOBIN-YVON, France), respectively. VOC species were analyzed by a gas chromatograph with a mass spectrometer and flame ionization detector (GC-MS/FID, TH_PKU-300, China).

183 **Table S1.** Source classification and emission factors.

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
Stationary combustion sources	Power plants	Coal	Grate-fired boilers	g·kg^{-1}-fuel	2×S×Cs	3.88	2.50	0.03	26×A	10×A	0.03	Local measurements (Yao et al.,
			Pulverized coal boilers	g·kg^{-1}-fuel	2×S×Cs	6.28	0.25	0.03	201×A	25×A	0.03	2009; Zhao et al., 2010; Wang et
			FBC boilers	g·kg^{-1}-fuel	2×S×Cs	2.00	0.27	0.03	154×A	45×A	0.03	al., 2011; Sun, 2015); USEPA, 2002; EEA, 2013
		Natural gas	–	g·m^{-3}-fuel	2×S×Cs	4.48	1.34	0.09	0.03	0.03	–	USEPA, 2002
		Solid waste	–	g·kg^{-1}-fuel	2×S×Cs	1.07	0.04	0.01	1.50	1.00	–	EEA, 2013
	Boilers	Coal	Grate-fired boilers	g·kg^{-1}-fuel	2×S×Cs	2.17	7.63	0.03	3.88×A	1.60×A	0.01	Local measurements (Lou, 2014;
			Pulverized coal boilers	g·kg^{-1}-fuel	2×S×Cs	6.54	0.25	0.03	129×A	19×A	0.01	Xu et al., 2018); Zhao et al., 2010;
			FBC boilers	g·kg^{-1}-fuel	2×S×Cs	2.00	0.27	0.03	154×A	45×A	0.01	USEPA, 2002; EEA, 2013
		Fuel oil	–	g·kg^{-1}-fuel	2×S×Cs	2.47	0.62	0.04	0.74	0.48	0.13	USEPA, 2002; EEA, 2013
		Diesel	–	g·kg^{-1}-fuel	2×S×Cs	2.82	0.71	0.04	0.14	0.04	–	USEPA, 2002
		Natural gas	–	g·m^{-3}-fuel	2×S×Cs	1.60	1.34	0.09	0.03	0.03	–	USEPA, 2002
		Biomass	–	g·kg^{-1}-fuel	2×S×Cs	3.52	4.32	0.12	3.07	2.59	0.15	USEPA, 2002
Industrial process sources	Mining	Coal mining	–	g·kg^{-1}-products	–	–	–	–	0.24	0.09	–	USEPA, 2002
		Oil and gas extraction	Oil	g·kg^{-1}-products	–	–	–	1.42	–	–	–	MEP, 2014
			Natural gas	g·kg^{-1}-products	–	–	–	0.50	–	–	–	MEP, 2014
		Metal mining	–	g·kg^{-1}-products	–	–	–	–	2.23	1.11	–	USEPA, 2002
		Non-metallic mining	–	g·kg^{-1}-products	–	–	–	–	0.09	0.02	–	USEPA, 2002
	Agricultural products processing	Grain grinding	–	g·kg^{-1}-products	–	–	–	–	0.13	0.06	–	USEPA, 2002
		Feed processing	–	g·kg^{-1}-products	–	–	–	1.00	0.93	0.47	–	USEPA, 2002; EEA, 2013
		Vegetable oil processing	–	g·kg^{-1}-products	–	–	–	4.00	–	–	–	USEPA, 2002

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
		Sugar production	–	g·kg^{-1}-products	–	–	–	0.20	0.52	0.26	–	EEA, 2013
		Meat processing	–	g·kg^{-1}-products	–	–	–	0.52	–	–	–	EEA, 2013
		Nut processing	–	g·kg^{-1}-products	–	–	–	–	0.53	0.26	–	USEPA, 2002
	Food manufacturing	Baked goods manufacturing	Bread	g·kg^{-1}-products	–	–	–	4.71	–	–	–	EEA, 2013
			Biscuits	g·kg^{-1}-products	–	–	–	1.00	–	–	–	MEP, 2014
	Beverage manufacturing	Alcohol	–	g·kg^{-1}-products	–	–	–	32.11	–	–	–	USEPA, 2002
		Liquor	–	g·kg^{-1}-products	–	–	–	14.45	–	–	–	USEPA, 2002
		Red wine	–	g·kg^{-1}-products	–	–	–	3.85	–	–	–	USEPA, 2002
		Beer	–	g·kg^{-1}-products	–	–	–	0.25	–	–	–	MEP, 2014
	Tobacco manufacturing	Tobacco	–	g·kg^{-1}-products	–	–	–	0.17	–	–	–	USEPA, 2002
	Wood processing	Plywood	–	g·m^{-3}-products	–	–	–	0.25	0.03	0.02	–	USEPA, 2002
		Oriented strand board	–	g·kg^{-1}-products	–	–	–	0.26	0.04	0.02	–	USEPA, 2002
		Particleboard	–	g·kg^{-1}-products	–	–	–	0.92	0.05	0.02	–	USEPA, 2002
		Fiberboard	–	g·kg^{-1}-products	–	–	–	1.02	0.05	0.02	–	USEPA, 2002
		Other wood products	–	g·kg^{-1}-products	–	–	–	0.10	0.01	0.00	–	USEPA, 2002
	Papermaking	Pulp manufacturing	–	g·kg^{-1}-products	11.38	–	5.55	0.66	3.14	2.44	–	USEPA, 2002
	Petroleum refining	Process devices	–	g·kg^{-1}-materials	–	–	–	0.44	–	–	–	Local surveys
		Equipment leak	–	g·kg^{-1}-materials	–	–	–	0.48	–	–	–	Local surveys
		Storage tanks	–	g·kg^{-1}-materials	–	–	–	0.45	–	–	–	Local surveys
		Bulk loading	–	g·kg^{-1}-materials	–	–	–	0.13	–	–	–	Local surveys
		Flares	–	g·kg^{-1}-materials	–	–	–	0.001	–	–	–	EEA, 2013
		Wastewater treatment	–	g·kg^{-1}-materials	–	–	–	0.25	–	–	–	Local surveys

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
		Cooling Tower	–	g·kg^{-1}-materials	–	–	–	0.02	–	–	–	Local surveys
		Petrochemical furnace	Refinery dry gas	g·kg^{-1}-fuel	–	7.78	1.01	0.37	0.04	0.04	–	USEPA, 2002
	Coking	Coke production	Coke oven	g·kg^{-1}-materials	1.47	0.82	0.34	0.05	0.14	0.14	–	USEPA, 2002
			Fugitive emission	g·kg^{-1}-materials	0.12	0.01	15.04	0.04	2.94	1.86	–	USEPA, 2002
	Chemical manufacturing	Organic chemical manufacturing	Overall	g·kg^{-1}-products	–	–	–	17.61	–	–	–	USEPA, 2002
		Inorganic chemical manufacturing	Sulfuric acid	g·kg^{-1}-products	15.28	–	–	–	–	–	–	USEPA, 2002
			Nitric acid	g·kg^{-1}-products	–	4.71	–	–	–	–	–	USEPA, 2002
			Calcium carbide	g·kg^{-1}-materials	3.00	–	–	–	5.82	2.91	–	USEPA, 2002
		Fertilizer	Synthetic ammonia	g·kg^{-1}-products	0.03	–	7.90	4.72	–	–	2.10	USEPA, 2002
			Urea	g·kg^{-1}-products	–	–	–	–	1.31	0.81	10.51	USEPA, 2002
			NPK Fertilizer	g·kg^{-1}-products	–	–	–	–	0.29	0.20	1.89	EEA, 2013
		Pesticide	–	g·m^{-3}-products	–	–	–	0.001	–	–	–	USEPA, 2002
		Coating production	Solvent-based coating	g·kg^{-1}-products	–	–	–	15.00	–	–	–	USEPA, 2002
			Waterborne coating	g·kg^{-1}-products	–	–	–	3.00	–	–	–	Local surveys
			Varnish	g·kg^{-1}-products	–	–	–	46.25	–	–	–	USEPA, 2002
		Ink production	Oily ink	g·kg^{-1}-products	–	–	–	75.00	–	–	–	USEPA, 2002
			Water-based ink	g·kg^{-1}-products	–	–	–	15.00	–	–	–	Local surveys
			Mineral ink	g·kg^{-1}-products	–	–	–	20.00	–	–	–	USEPA, 2002
		Synthetic resin	Overall	g·kg^{-1}-products	–	–	–	5.77	–	–	–	USEPA, 2002; EEA, 2013
		Synthetic rubber	Overall	g·kg^{-1}-products	–	–	–	4.18	–	–	–	USEPA, 2002
		Synthetic fiber monomer	Overall	g·kg^{-1}-products	–	–	–	48.79	–	–	–	USEPA, 2002; MEP, 2014
		Specialty chemicals	Adhesive	g·kg^{-1}-products	–	–	–	227.00	–	–	–	USEPA, 2002

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
			Accelerator	g·kg^{-1}-products	–	–	–	1.87	–	–	–	USEPA, 2002
			Carbon black	g·kg^{-1}-products	7.13	1.08	720.49	26.20	1.31	0.65	–	USEPA, 2002
			Charcoal	g·kg^{-1}-products	–	12.00	145.00	135.00	12.80	6.40	–	USEPA, 2002
		Explosive	Overall	g·kg^{-1}-products	22.94	30.58	–	–	0.72	0.36	–	USEPA, 2002
		Household chemicals	Active agent	g·kg^{-1}-products	–	–	–	0.98	–	–	–	USEPA, 2002
			Spices	g·kg^{-1}-products	–	–	–	22.89	–	–	–	Local surveys
		Chemical fiber	Synthetic fiber manufacturing	g·kg^{-1}-products	–	–	–	42.31	–	–	–	USEPA, 2002
			Synthetic fiber processing	g·kg^{-1}-products	–	–	–	0.36	–	–	–	USEPA, 2002
	Pharmaceutical manufacturing	Chemical drug	–	g·kg^{-1}-products	–	–	–	260.00	–	–	–	MEP, 2014
	Rubber and plastic manufacturing	Rubber products	Tire	g·tire^{-1}	–	–	–	329.60	–	–	–	USEPA, 2002
			General rubber products	g·kg^{-1}-products	–	–	–	6.64	–	–	–	USEPA, 2002
		Plastic products	General plastic products	g·kg^{-1}-materials	–	–	–	0.54	–	–	–	USEPA, 2002
			Foam plastic	g·kg^{-1}-products	–	–	–	0.77	–	–	–	MEP, 2014
			Poly urethane	g·kg^{-1}-products	–	–	–	147.00	–	–	–	USEPA, 2002
			Polyvinyl chloride	g·kg^{-1}-products	–	–	–	10.20	–	–	–	USEPA, 2002
			Plastic tape	g·m^{-2}-products	–	–	–	9.00	–	–	–	USEPA, 2002
	Non-metallic mineral manufacturing	Cement manufacturing	Cement kiln	g·kg^{-1}-products	0.11	2.10	1.80	0.06	3.81	1.17	–	USEPA, 2002
			Fugitive emission	g·kg^{-1}-products	–	–	–	–	0.24	0.05	–	USEPA, 2002
		Lime manufacturing	Lime kiln	g·kg^{-1}-products	2.70	1.60	0.74	–	22.00	2.52	–	USEPA, 2002
			Fugitive emission	g·kg^{-1}-products	–	–	–	–	11.54	1.33	–	USEPA, 2002
		Plaster manufacturing	–	g·kg^{-1}-products	–	–	–	–	8.22	1.78	–	USEPA, 2002
		Gypsum board	–	g·m^{-2}-products	–	–	–	–	8.76	4.38	–	USEPA, 2002

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
		Commodity concrete	–	g·kg^{-1}-products	–	–	–	–	1.13	0.56	–	USEPA, 2002
		Brick and tile products	Brick kiln	g·kg^{-1}-products	0.60	0.26	0.40	0.01	0.38	0.14	–	USEPA, 2002
			Fugitive emission	g·kg^{-1}-products	–	–	–	0.02	0.43	0.21	–	USEPA, 2002
		Crushed Stone processing	–	g·kg^{-1}-products	–	–	–	–	0.05	0.02	–	USEPA, 2002
		Abrasive processing	–	g·kg^{-1}-materials	–	–	–	–	0.03	0.01	–	USEPA, 2002
		Asphalt products	–	g·kg^{-1}-products	0.03	0.03	0.13	0.01	0.91	0.16	–	USEPA, 2002
		Glass products	Container glass	g·kg^{-1}-products	–	–	8.70	4.40	0.53	0.37	–	USEPA, 2002
			Plate glass	g·kg^{-1}-products	–	–	–	–	0.75	0.53	–	USEPA, 2002
			Glass fiber	g·kg^{-1}-materials	–	–	–	0.15	1.33	0.66	–	USEPA, 2002
		Ceramic products	–	g·kg^{-1}-products	–	–	–	29.00	5.41	2.71	–	USEPA, 2002
		Refractory products	–	g·kg^{-1}-materials	–	–	–	–	22.10	5.10	–	USEPA, 2002
	Ferrous metal manufacturing	Raw material yard	–	g·kg^{-1}-materials	–	–	–	–	0.71	0.11	–	Local measurements
		Iron making	Sintering	g·kg^{-1}-sinter	1.05	0.97	22.00	0.07	2.44	1.05	–	Local measurements (Guo et al., 2017)
			Pellet	g·kg^{-1}-pellet	0.90	0.03	0.06	0.01	0.75	0.32	–	
			Blast furnace	g·kg^{-1}-iron	–	–	–	–	1.96	1.06	–	
		Steel making	Converter	g·kg^{-1}-steel	–	–	–	–	1.63	1.13	–	Local measurements (Guo et al., 2017)
			Electric furnace	g·kg^{-1}-steel	–	–	–	–	0.18	0.09	–	
		Casing steel	–	g·kg^{-1}-products	–	–	–	–	6.58	3.29	–	USEPA, 2002
		Rolling steel	–	g·kg^{-1}-products	–	–	–	0.25	0.05	0.02	–	USEPA, 2002
		Ferroalloy production	–	g·kg^{-1}-products	–	–	–	–	99.29	84.72	–	USEPA, 2002
	Non-ferrous metal manufacturing	Primary copper	–	g·kg^{-1}-products	0.67	–	–	–	2.81	1.71	–	USEPA, 2002
		Primary aluminum	–	g·kg^{-1}-products	–	–	–	–	2.75	2.13	–	USEPA, 2002

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
		Primary lead	–	g·kg^{-1}-products	–	–	–	–	1.25	0.63	–	EEA, 2013
		Primary zinc	–	g·kg^{-1}-products	–	–	–	–	0.40	0.30	–	EEA, 2013
		Secondary copper	–	g·kg^{-1}-materials	–	–	–	–	60.41	30.20	–	USEPA, 2002
		Secondary aluminum	–	g·kg^{-1}-products	–	–	–	–	6.97	5.20	–	USEPA, 2002
		Secondary lead	–	g·kg^{-1}-materials	–	–	–	–	4.75	2.38	–	USEPA, 2002
		Secondary zinc	–	g·kg^{-1}-products	–	–	–	–	23.89	11.94	–	USEPA, 2002
	Other miscellaneous sources	Explosives detonation	–	g·kg^{-1}-materials	1.00	17.00	114.11	–	–	–	12.43	USEPA, 2002
		Abrasive blasting	–	g·kg^{-1}-products	–	–	–	–	13.00	1.30	–	USEPA, 2002
		Electric arc welding	–	g·kg^{-1}-materials	–	–	–	–	12.46	6.23	–	USEPA, 2002
Industrial solvent-use sources	–	–	–	–	Calculated based on solvent consumption							
Mobile sources	Motor vehicles	Light-duty gasoline vehicles	Euro 0	g·km^{-1}	–	2.80	28.68	6.53	0.12	0.12	0.00	Local measurements (Huang et al., 2017; Huang et al., 2018a; Huang et al., 2018b)
			Euro 1	g·km^{-1}	–	1.23	13.52	3.59	0.14	0.14	0.08	
			Euro 2	g·km^{-1}	–	0.93	10.28	2.37	0.14	0.14	0.07	
			Euro 3	g·km^{-1}	–	0.52	7.11	0.85	0.03	0.03	0.04	
			Euro 4	g·km^{-1}	–	0.20	2.36	0.28	0.01	0.01	0.03	
			Euro 5	g·km^{-1}	–	0.16	2.01	0.26	0.01	0.01	0.02	
		Light-duty diesel vehicles	Euro 0	g·km^{-1}	–	1.99	10.05	2.36	1.19	1.07	–	Estimated based on the International Vehicle Emission (IVE) Model (Huang et al., 2015)
			Euro 1	g·km^{-1}	–	1.46	2.70	0.43	0.42	0.38	–	
			Euro 2	g·km^{-1}	–	1.46	3.38	0.28	0.35	0.31	–	
			Euro 3	g·km^{-1}	–	1.26	1.05	0.14	0.22	0.19	–	
			Euro 4	g·km^{-1}	–	1.02	0.98	0.10	0.20	0.19	–	
			Euro 5	g·km^{-1}	–	1.02	0.98	0.10	0.20	0.19	–	

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
		Heavy-duty gasoline vehicles	Euro 0	g·km^{-1}	–	5.16	100.74	16.29	0.65	0.59	0.00	Estimated based on the International Vehicle Emission (IVE) Model (Huang et al., 2015)
			Euro 1	g·km^{-1}	–	2.65	62.09	11.37	0.35	0.32	0.08	
			Euro 2	g·km^{-1}	–	2.56	33.28	6.80	0.16	0.14	0.07	
			Euro 3	g·km^{-1}	–	1.52	16.50	4.34	0.10	0.09	0.04	
			Euro 4	g·km^{-1}	–	0.78	7.54	2.53	0.10	0.09	0.03	
			Euro 5	g·km^{-1}	–	0.58	7.54	2.53	0.10	0.09	0.02	
		Heavy-duty diesel vehicles	Euro 0	g·km^{-1}	–	12.42	26.33	5.34	3.22	2.89	–	Estimated based on the International Vehicle Emission (IVE) Model (Huang et al., 2015)
			Euro 1	g·km^{-1}	–	11.16	24.65	4.61	2.46	2.21	–	
			Euro 2	g·km^{-1}	–	9.89	21.70	2.81	2.21	1.98	–	
			Euro 3	g·km^{-1}	–	9.89	16.85	1.13	0.99	0.89	–	
			Euro 4	g·km^{-1}	–	9.89	8.13	0.86	0.63	0.57	–	
			Euro 5	g·km^{-1}	–	8.64	4.05	0.86	0.32	0.28	–	
		Heavy-duty gasoline truck	Euro 0	g·km^{-1}	–	7.26	153.91	18.07	0.82	0.73	0.00	Estimated based on the International Vehicle Emission (IVE) Model (Huang et al., 2015)
			Euro 1	g·km^{-1}	–	3.72	94.74	17.80	0.44	0.40	0.08	
			Euro 2	g·km^{-1}	–	3.63	36.44	8.42	0.20	0.18	0.07	
			Euro 3	g·km^{-1}	–	2.14	16.73	4.29	0.12	0.11	0.04	
			Euro 4	g·km^{-1}	–	1.13	7.03	2.29	0.12	0.11	0.03	
			Euro 5	g·km^{-1}	–	0.85	7.03	2.29	0.12	0.11	0.02	
		Heavy-duty diesel truck	Euro 0	g·km^{-1}	–	16.75	10.54	8.46	2.24	2.04	–	Estimated based on the International Vehicle Emission (IVE) Model (Huang et al., 2015)
			Euro 1	g·km^{-1}	–	11.62	6.73	3.72	1.60	1.44	–	
			Euro 2	g·km^{-1}	–	9.61	3.58	2.16	1.29	1.16	–	
			Euro 3	g·km^{-1}	–	9.61	3.24	1.06	0.88	0.79	–	
			Euro 4	g·km^{-1}	–	8.41	2.56	0.67	0.47	0.43	–	

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
			Euro 5	g·km^{-1}	–	7.15	2.56	0.67	0.30	0.27	–	
		Taxi	Euro 0	g·km^{-1}	–	2.80	43.03	7.74	0.18	0.18	0.00	Estimated based on the International Vehicle Emission (IVE) Model (Huang et al., 2015)
			Euro 1	g·km^{-1}	–	2.46	20.28	4.21	0.21	0.21	0.08	
			Euro 2	g·km^{-1}	–	2.32	15.42	2.76	0.21	0.21	0.07	
			Euro 3	g·km^{-1}	–	1.55	10.67	1.95	0.05	0.05	0.04	
			Euro 4	g·km^{-1}	–	0.44	3.54	0.91	0.02	0.02	0.03	
			Euro 5	g·km^{-1}	–	0.41	3.01	0.84	0.01	0.01	0.02	
		Bus	Euro 0	g·km^{-1}	–	22.26	20.18	7.39	2.79	2.51	–	Local measurements (Huang et al., 2016)
			Euro 1	g·km^{-1}	–	19.99	18.90	3.19	2.13	1.92	–	
			Euro 2	g·km^{-1}	–	17.73	16.64	1.95	1.91	1.72	–	
			Euro 3	g·km^{-1}	–	17.73	12.92	1.57	0.86	0.77	–	
			Euro 4	g·km^{-1}	–	16.65	9.58	1.01	0.65	0.59	–	
			Euro 5	g·km^{-1}	–	14.54	5.25	0.57	0.45	0.41	–	
		Motorcycles	Euro 0	g·km^{-1}	–	0.13	21.30	4.47	0.07	0.06	–	Estimated based on the International Vehicle Emission (IVE) Model (Huang et al., 2015)
			Euro 1	g·km^{-1}	–	0.14	13.44	2.43	0.04	0.04	–	
			Euro 2	g·km^{-1}	–	0.15	3.87	1.51	0.02	0.02	–	
			Euro 3	g·km^{-1}	–	0.10	1.67	0.87	0.01	0.01	–	
	Non-road machinery	Construction machinery	Euro 0	g·kg^{-1}-fuel	0.61	61.82	20.75	6.64	3.85	3.65	–	Estimated based on the NONROAD Model and local measurements (Lu et al., 2017)
			Euro 1	g·kg^{-1}-fuel	0.61	49.81	14.03	3.85	2.63	2.50	–	
			Euro 2	g·kg^{-1}-fuel	0.61	37.47	11.93	2.95	1.69	1.60	–	
			Euro 3	g·kg^{-1}-fuel	0.61	25.60	11.41	2.44	1.27	1.20	–	
		Port machinery	Euro 0	g·kg^{-1}-fuel	0.55	44.17	16.10	5.10	3.30	3.14	–	
			Euro 1	g·kg^{-1}-fuel	0.55	36.10	10.74	2.84	2.28	2.17	–	

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
			Euro 2	g·kg^{-1}-fuel	0.55	27.42	9.47	2.47	1.36	1.29	–	Estimated based on the NONROAD Model and local measurements (Lu et al., 2017)
			Euro 3	g·kg^{-1}-fuel	0.55	17.68	8.95	1.88	1.02	0.97	–	
		Factory machinery	Euro 0	g·kg^{-1}-fuel	0.45	61.82	20.75	6.64	3.85	3.65	–	Estimated based on the NONROAD Model and local measurements (Lu et al., 2017)
			Euro 1	g·kg^{-1}-fuel	0.45	49.81	14.03	3.85	2.63	2.50	–	
			Euro 2	g·kg^{-1}-fuel	0.45	37.47	11.93	2.95	1.69	1.60	–	
			Euro 3	g·kg^{-1}-fuel	0.45	25.60	11.41	2.44	1.27	1.20	–	
		Agricultural machinery	Euro 0	g·kg^{-1}-fuel	0.52	56.63	39.43	11.86	5.12	4.86	–	Estimated based on the NONROAD Model and local measurements (Lu et al., 2017)
			Euro 1	g·kg^{-1}-fuel	0.52	45.46	25.81	6.47	3.49	3.32	–	
			Euro 2	g·kg^{-1}-fuel	0.52	35.89	21.07	4.85	2.50	2.38	–	
			Euro 3	g·kg^{-1}-fuel	0.52	25.35	17.10	3.23	2.21	2.10	–	
		Garden equipment	Euro 0	g·kg^{-1}-fuel	–	5.54	787.07	118.15	1.84	1.84	–	Estimated based on the NONROAD Model and local measurements (Lu et al., 2017)
			Euro 1	g·kg^{-1}-fuel	–	6.77	802.04	75.16	1.34	1.34	–	
			Euro 2	g·kg^{-1}-fuel	–	4.77	703.52	64.46	0.76	0.76	–	
			Euro 3	g·kg^{-1}-fuel	–	3.57	641.19	51.61	0.58	0.58	–	
		Ground handling equipment	Euro 0	g·kg^{-1}-fuel	0.70	61.82	20.75	6.64	3.85	3.65	–	Estimated based on the NONROAD Model and local measurements (Lu et al., 2017)
			Euro 1	g·kg^{-1}-fuel	0.70	49.81	14.03	3.85	2.63	2.50	–	
			Euro 2	g·kg^{-1}-fuel	0.70	37.47	11.93	2.95	1.69	1.60	–	
			Euro 3	g·kg^{-1}-fuel	0.70	25.60	11.41	2.44	1.27	1.20	–	
	Marine	–	–	–	Detailed emission factors can be referred to Fan et al., 2016							
	Aviation aircraft	–	–	–	Detailed emission factors can be referred to ICAO, 2014							
Dust sources	Construction dust	–	–	g·m^{-2}·month^{-1}	–	–	–	–	78.03	19.36	–	MEP, 2014
	Road dust	highways	–	g·km^{-1}	–	–	–	–	0.51	0.12	–	MEP, 2014

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
		Elevated roads	–	$g \cdot km^{-1}$	–	–	–	–	1.53	0.37	–	MEP, 2014
		Arterial roads	–	$g \cdot km^{-1}$	–	–	–	–	0.94	0.23	–	MEP, 2014
		Residential roads	–	$g \cdot km^{-1}$	–	–	–	–	0.82	0.20	–	MEP, 2014
Oil storage and transportation	Oil depot	Storage and transportation process	Crude oil	$g \cdot kg^{-1}$-turnover	–	–	–	0.44	–	–	–	
			Gasoline	$g \cdot kg^{-1}$-turnover	–	–	–	1.69	–	–	–	
			Diesel	$g \cdot kg^{-1}$-turnover	–	–	–	0.65	–	–	–	Local surveys
			Heavy oil	$g \cdot kg^{-1}$-turnover	–	–	–	0.13	–	–	–	
			Chemicals	$g \cdot kg^{-1}$-turnover	–	–	–	0.84	–	–	–	
	Gas station	Storage and transportation process	Gasoline	$g \cdot kg^{-1}$-fuel	–	–	–	1.43	–	–	–	Local surveys
Residential sources	Residential combustion	Bituminous coal	–	$g \cdot kg^{-1}$-fuel	2×S×Cs	1.57	125.45	4.18	15.89	14.22	1.01	
		Anthracite coal	–	$g \cdot kg^{-1}$-fuel	2×S×Cs	1.50	125.45	4.18	7.53	2.64	1.01	MEP, 2014; Li et al., 2016; USEPA, 2002; EEA, 2013
		Coal gas	–	$g \cdot m^{-3}$-fuel	–	1.50	1.34	0.09	0.05	0.05	–	
		Natural gas	–	$g \cdot m^{-3}$-fuel	–	1.60	1.34	0.09	0.03	0.03	–	
		Biogas	–	$g \cdot m^{-3}$-fuel	–	0.59	0.75	0.05	0.03	0.03	–	
	Residential solvent-use	Architectural coating	Solvent-based coating	$g \cdot kg^{-1}$-coatings	–	–	–	600.00	–	–	–	Local surveys
			Waterborne coating	$g \cdot kg^{-1}$-coatings	–	–	–	65.00	–	–	–	Local surveys
		Consumer products	–	$g \cdot capita^{-1}$	–	–	–	100.00	–	–	–	MEP, 2014
		Solvent degreasing	–	$g \cdot capita^{-1}$	–	–	–	44.00	–	–	–	MEP, 2014
		Auto repair	–	$g \cdot vehicle^{-1}$	–	–	–	20.02	–	–	–	Local surveys
		Dry cleaning	–	$g \cdot capita^{-1}$	–	–	–	24.36	–	–	–	Local surveys
		Hospital solvent	–	$g \cdot outpatient^{-1}$	–	–	–	16.00	–	–	–	Local surveys

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
	Catering	–	–	kg·restaurant^{-1}	–	–	–	95.34	41.30	33.04	–	Local measurements (Wang et al., 2018; Gao et al., 2019)
	Human excretion	–	–	kg·capita^{-1}	–	–	–	–	–	–	0.79	MEP, 2014
Waste treatment and disposal	Sewage treatment	–	–	g·t^{-1}-wastewater	–	–	–	1.10	–	–	3.20	MEP, 2014
	Waste treatment	Landfill	–	g·kg^{-1}-refuse	–	–	–	0.23	–	–	0.56	MEP, 2014
		Composting	–	g·kg^{-1}-refuse	–	–	–	0.74	–	–	1.28	MEP, 2014
Agricultural sources	Livestock and poultry breeding	Swine breeding	Shed	g·head^{-1}·d^{-1}	–	–	–	–	–	–	7.97	Local measurements (Chen, 2017a)
			Manure fertilizing	g·head^{-1}·d^{-1}	–	–	–	–	–	–	1.80	
			Sewage storage	g·head^{-1}·d^{-1}	–	–	–	–	–	–	1.68	
			Apply fertilizer	g·head^{-1}·d^{-1}	–	–	–	–	–	–	1.80	
		Dairy cow breeding	Shed	g·head^{-1}·d^{-1}	–	–	–	–	–	–	33.80	Local measurements (Zhou, 2019)
			Manure fertilizing	g·head^{-1}·d^{-1}	–	–	–	–	–	–	17.40	
			Sewage storage	g·head^{-1}·d^{-1}	–	–	–	–	–	–	25.70	
			Apply fertilizer	g·head^{-1}·d^{-1}	–	–	–	–	–	–	93.80	
		Beef cattle	Shed	g·head^{-1}·d^{-1}	–	–	–	–	–	–	43.00	MEP, 2014
			Manure fertilizing	g·head^{-1}·d^{-1}	–	–	–	–	–	–	20.00	
			Sewage storage	g·head^{-1}·d^{-1}	–	–	–	–	–	–	20.00	
			Apply fertilizer	g·head^{-1}·d^{-1}	–	–	–	–	–	–	22.50	
		Sheep	Shed	g·head^{-1}·d^{-1}	–	–	–	–	–	–	12.10	MEP, 2014
			Manure fertilizing	g·head^{-1}·d^{-1}	–	–	–	–	–	–	5.60	
			Sewage storage	g·head^{-1}·d^{-1}	–	–	–	–	–	–	5.60	
			Apply fertilizer	g·head^{-1}·d^{-1}	–	–	–	–	–	–	6.30	

Source classification				Units	Emission factors							References
1st level	2nd level	3rd level	4th level		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3	
		Broiler	Shed	g·head-1·d-1	–	–	–	–	–	–	0.10	
			Manure fertilizing	g·head-1·d-1	–	–	–	–	–	–	0.10	MEP, 2014
			Apply fertilizer	g·head-1·d-1	–	–	–	–	–	–	0.03	
		Egg-laying poultry	Shed	g·head-1·d-1	–	–	–	–	–	–	1.40	
			Manure fertilizing	g·head-1·d-1	–	–	–	–	–	–	0.90	MEP, 2014
			Apply fertilizer	g·head-1·d-1	–	–	–	–	–	–	0.27	
	N-fertilizer application	Paddy field	–	$g·kg^{-1}$-fertilizer	–	–	–	–	–	–	243.40	Local measurements (Chen et al., 2017b)
		Wheat field	–	$g·kg^{-1}$-fertilizer	–	–	–	–	–	–	74.70	Local measurements (Xia et al., 2018)
	Biomass burning	Field burning	Soybean	$g·kg^{-1}$-straw	0.53	1.08	32.30	8.45	1.98	1.84	0.53	
			Rape	$g·kg^{-1}$-straw	0.53	1.12	34.30	8.45	3.57	3.32	0.53	
			Rice stalk	$g·kg^{-1}$-straw	0.53	1.42	27.70	8.45	3.26	3.03	0.53	Local measurements (Tang et al., 2014); MEP, 2014
			Wheat stalk	$g·kg^{-1}$-straw	0.85	1.19	20.60	7.48	2.57	2.39	0.37	
			Corn stalk	$g·kg^{-1}$-straw	0.44	4.30	53.00	10.00	12.58	11.70	0.68	
		Household stove	Soybean	$g·kg^{-1}$-straw	1.36	2.19	80.70	7.97	8.29	7.71	0.52	
			Rape	$g·kg^{-1}$-straw	1.36	1.65	133.50	7.97	13.73	12.77	0.52	
			Rice stalk	$g·kg^{-1}$-straw	0.48	2.02	82.00	7.36	9.83	9.14	0.52	Local measurements (Tang et al.,
			Straw	$g·kg^{-1}$-straw	2.36	0.86	191.55	13.74	7.40	6.88	0.37	2014); MEP, 2014
			Corn stalk	$g·kg^{-1}$-straw	1.33	1.16	108.90	5.46	6.17	5.74	0.68	
			Firewood	$g·kg^{-1}$-straw	0.40	1.28	67.53	1.73	4.68	4.36	1.30	

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185 **Table S2.** Emission estimation methods and activity data sources.

No.	Sources		Estimation methods	Activity data source	Reliability level
	1st level	2nd level			
1	Stationary combustion sources	–	SO_2, PM_{10}, and $PM_{2.5}$: mass balance method; Other pollutants: emission factor method	2017 environmental statistics	A
2	Industrial process sources	–	Emission factor method	2017 environmental statistics	B
3	Industrial solvent-use sources	–	Mass balance method	2017 environmental statistics	C
4	Mobile sources	Motor vehicles	International Vehicle Emission (IVE) model	Local surveys	B
		Non-road machinery	Emission factor method	Estimated based on local surveys	D
		Ships	Automatic Identification System (AIS) method	2017 AIS data	B
		Aviation aircraft	Emission factor and FOA3.0 method (Wayson et al., 2009)	Local flight information surveys	B
5	Dust sources	Construction dust	Emission factor method	Estimated based on statistic yearbooks	D
		Road dust	Emission factor method	Local surveys	B
6	Oil storage and transportation sources	–	Emission factor method	Statistic yearbooks	C
7	Residential sources	Residential combustion	Emission factor method	Statistic yearbooks	C
		Residential solvent-use	Emission factor method	Estimated based on statistic yearbooks	D
		Catering	Emission factor method	Estimated based on statistic yearbooks	D
		Human excretion	Emission factor method	Estimated based on statistic yearbooks	D
8	Waste treatment and disposal sources	–	Emission factor method	Statistic yearbooks	C
9	Agricultural sources	Livestock and poultry breeding	Emission factor method	Statistic yearbooks	C
		N-fertilizer application	Emission factor method	Statistic yearbooks	C
		Biomass burning	Emission factor method	Estimated based on statistic yearbooks	D

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187 **Table S3.** Emission estimation methods and activity data sources.

Source classification			$PM_{2.5}$ speciation			NMVOC speciation		
1st level	2nd level	3rd level	References	Samples	Analytical method	References	Samples	Methods
Stationary combustion	Power plants	Coal	Local measurements (Zheng et al., 2013)	2	CA; IC; ICPAES	Local measurements	2	GC-FID/MS
sources		Natural gas	SPECIATE 4.4			SPECIATE 4.4		
		Solid waste	SPECIATE 4.4			Reference to coal		
	Boilers	Coal	Local measurements (Xu et al., 2018)	7	CA; IC; ICPAES	SPECIATE 4.4		
		Fuel oil	SPECIATE 4.4			SPECIATE 4.4		
		Diesel	SPECIATE 4.4			SPECIATE 4.4		
		Natural gas	SPECIATE 4.4			SPECIATE 4.4		
		Biomass	Local measurements	2	CA; IC; XRF	Local measurements	7	GC-FID/MS
Industrial process	Mining	Coal mining	Local measurements	2	CA; IC; ICPAES	/		
source		Oil and gas extraction	/			SPECIATE 4.4		
		Metal mining	SPECIATE 4.4			/		
		Non-metallic mining	Local measurements	2	CA; IC; ICPAES	/		
	Agricultural products processing	–	SPECIATE 4.4			Local measurements (Gao et al., 2019)	27	GC-FID/MS
	Food manufacturing	–	/			Local measurements (Gao et al., 2019)	27	GC-FID/MS
	Beverage manufacturing	Alcohol	/			SPECIATE 4.4		
		Liquor	/			SPECIATE 4.4		
		Red wine	/			SPECIATE 4.4		
		Beer	/			SPECIATE 4.4		
	Tobacco manufacturing	Tobacco	/			SPECIATE 4.4		
	Wood processing	–	SPECIATE 4.4			SPECIATE 4.4		
	Papermaking	Pulp manufacturing	SPECIATE 4.4			Local measurements	2	GC-FID/MS

Petroleum refining	Process devices	/			Local measurements (Wang et al., 2017a)	21	GC-FID/MS
	Equipment leak	/			Local measurements (Wang et al., 2017a)	21	GC-FID/MS
	Storage tanks	/			Local measurements (Wang et al., 2017a)	8	GC-FID/MS
	Loading and unloading	/			Local measurements (Wang et al., 2017a)	8	GC-FID/MS
	Flares	/			SPECIATE 4.4		
	Wastewater treatment	/			Local measurements (Wang et al., 2017a)	6	GC-FID/MS
	Cooling Tower	/			SPECIATE 4.4		
	Petrochemical furnace	/			SPECIATE 4.4		
Coking	Coke production	Local measurements	2	CA; IC; ICPAES	Local measurements (Wang et al., 2017a; Jing et al., 2018)	4	GC-FID/MS
Chemical manufacturing	Organic chemical manufacturing	/			Local measurements (Wang et al., 2017a; Jing et al., 2018)	32	GC-FID/MS
	Inorganic chemical manufacturing	SPECIATE 4.4			/		
	Fertilizer	SPECIATE 4.4			/		
	Pesticide	/			SPECIATE 4.4		
	Coating production	/			Local measurements (Wang et al., 2017a; Jing et al., 2018)	10	GC-FID/MS
	Ink production	/			Local measurements (Wang et al., 2017a; Jing et al., 2018)	22	GC-FID/MS
	Synthetic resin	/			Local measurements (Wang et al., 2017a; Jing et al., 2018)	2	GC-FID/MS
	Synthetic rubber	/			Local measurements (Wang et al., 2017a; Jing et al., 2018)	6	GC-FID/MS
	Synthetic fiber monomer	/			Local measurements (Wang et al., 2017a; Jing et al., 2018)	2	GC-FID/MS
	Specialty chemicals	SPECIATE 4.4			SPECIATE 4.4		
	Household chemicals	/			SPECIATE 4.4		
	Chemical fiber	/			Local measurements (Wang et al., 2017a; Jing et al., 2018)	2	GC-FID/MS
Rubber and plastic manufacturing	Rubber products	/			Local measurements (Wang et al., 2017a; Jing et al., 2018)	6	GC-FID/MS
	Plastic products	/			Local measurements (Wang et al., 2017a; Jing et al., 2018)	2	GC-FID/MS
Non-metallic mineral manufacturing	Cement manufacturing	SPECIATE 4.4			/		
	Lime manufacturing	SPECIATE 4.4			/		

	Plaster manufacturing	SPECIATE 4.4			/
	Gypsum board	SPECIATE 4.4			/
	Commodity concrete	Local measurements	2	CA; IC; ICPAES	/
	Brick and tile products	SPECIATE 4.4			/
	Crushed Stone processing	SPECIATE 4.4			/
	Abrasive processing	SPECIATE 4.4			/
	Asphalt products	SPECIATE 4.4			SPECIATE 4.4
	Glass products	SPECIATE 4.4			/
	Glass fiber	SPECIATE 4.4			/
	Ceramic products	SPECIATE 4.4			SPECIATE 4.4
	Refractory products	SPECIATE 4.4			/
Ferrous metal manufacturing	Raw material yard	Local measurements	2	CA; IC; XRF	/
	Sintering	Local measurements	4	CA; IC; XRF	SPECIATE 4.4
	Pellet	Local measurements	2	CA; IC; XRF	SPECIATE 4.4
	Blast furnace	Local measurements	3	CA; IC; XRF	SPECIATE 4.4
	Converter	Local measurements	2	CA; IC; XRF	SPECIATE 4.4
	Electric furnace	SPECIATE 4.4			SPECIATE 4.4
	Casing steel	SPECIATE 4.4			SPECIATE 4.4
	Rolling steel	SPECIATE 4.4			SPECIATE 4.4
	Ferroalloy production	SPECIATE 4.4			/
Non-ferrous metal manufacturing	Primary copper	SPECIATE 4.4			/
	Primary aluminum	SPECIATE 4.4			/
	Primary lead	SPECIATE 4.4			/
	Primary zinc	SPECIATE 4.4			/
	Secondary copper	SPECIATE 4.4			/

		Secondary aluminum	SPECIATE 4.4			SPECIATE 4.4		
		Secondary lead	SPECIATE 4.4			/		
		Secondary zinc	SPECIATE 4.4			/		
	Other miscellaneous sources	Abrasive blasting	SPECIATE 4.4			/		
		Electric arc welding	SPECIATE 4.4			/		
Industrial solvent-use	Textile	–				Local measurements (Wang et al., 2017a; Jing et al., 2018)	14	GC-FID/MS
source	Leather tanning	–				SPECIATE 4.4		
	Furniture manufacturing	–				Local measurements (Wang et al., 2017a; Jing et al., 2018)	6	GC-FID/MS
	Package and printing	–				Local measurements (Wang et al., 2017a; Jing et al., 2018)	8	GC-FID/MS
	Pharmaceutical manufacturing	–				SPECIATE 4.4		
	Shoemaking	–				Local measurements (Wang et al., 2017a; Jing et al., 2018)	6	GC-FID/MS
	Metal products	–				Local measurements (Wang et al., 2017a; Jing et al., 2018)	12	GC-FID/MS
	Machinery manufacturing	–				Reference to Metal products		
	Railway equipment	–				SPECIATE 4.4		
	Auto manufacturing	–				Local measurements (Wang et al., 2017a; Jing et al., 2018)	25	GC-FID/MS
	Shipbuilding	–				Local measurements (Wang et al., 2017a; Jing et al., 2018)	28	GC-FID/MS
	Appliance manufacturing	–				SPECIATE 4.4		
	Electronic equipment	–				SPECIATE 4.4		
Mobile source	Motor vehicles	Light-duty gasoline vehicles (LDGV)	Local measurements	10	CA; IC; XRF	Local measurements (Wang et al., 2017b)	21	GC-FID/MS
		Light-duty diesel vehicles (LDDV)	Reference to HDDT			Reference to HDDT		
		Heavy-duty gasoline vehicles (HDGV)	Reference to LDGV			Reference to LDGV		
		Heavy-duty diesel vehicles (HDDV)	Reference to HDDT			Reference to HDDT		
		Heavy-duty gasoline truck (HDGT)	Reference to LDGV			Reference to LDGV		
		Heavy-duty diesel truck (HDDT)	Local measurements	15	CA; IC; XRF	Local measurements (Wang et al., 2017b)	16	GC-FID/MS
		Taxi	Reference to LDGV			Reference to LDGV		

		Bus	Reference to HDDT			Local measurements (Wang et al., 2017b)	6	GC-FID/MS
		Motorcycles	Reference to LDGV			Local measurements (Wang et al., 2017b)	7	GC-FID/MS
		Evaporative emission	/			Reference to Gas station		
	Non-road machinery	Construction machinery	Local measurements	10	CA; IC; XRF	Local measurements	10	GC-FID/MS
		Port machinery	Local measurements	2	CA; IC; XRF	Local measurements	2	GC-FID/MS
		Factory machinery	Local measurements	2	CA; IC; XRF	Local measurements	2	GC-FID/MS
		Agricultural machinery	Local measurements	2	CA; IC; XRF	Local measurements	2	GC-FID/MS
		Garden equipment				Reference to LDGV		
		Ground handling equipment (GHE)	Local measurements	2	CA; IC; XRF	Local measurements	2	GC-FID/MS
	Marine	Inland ship	Local measurements	2	CA; IC; XRF	Reference to non-road diesel machinery		
		Marine vessel	Local measurements	1	CA; IC; XRF	Local measurements (Huang et al., 2018c)	11	GC-FID/MS
	Aviation aircraft	–	SPECIATE 4.4			SPECIATE 4.4		
Dust source	Construction dust	–	Local measurements	3	CA; IC; ICPAES	/		
	Road dust	–	Local measurements	4	CA; IC; ICPAES	/		
Oil storage and	Oil depot	Crude oil	/			Local measurements (Wang et al., 2017a)	4	GC-FID/MS
transportation source		Gasoline	/			Local measurements (Wang et al., 2017a)	2	GC-FID/MS
		Diesel	/			Local measurements (Wang et al., 2017a)	2	GC-FID/MS
		Heavy oil	/			Reference to Crude oil		
		Chemicals	/			SPECIATE 4.4		
	Gas station	Gasoline	/			Local measurements (Wang et al., 2017a)	4	GC-FID/MS
Residential source	Residential combustion	–	Local measurements	2	CA; IC; ICPAES	SPECIATE 4.4		
	Residential solvent-use	Architectural coating	/			Local measurements (Wang et al., 2014b; Wang et al., 2016)	4	GC-FID/MS
		Consumer products	/			SPECIATE 4.4		
		Solvent degreasing	/			SPECIATE 4.4		
		Auto repair	/			Local measurements	4	GC-FID/MS

		Dry cleaning	/			SPECIATE 4.4		
		Hospital solvent	/			Local measurements		
	Catering	–	Local measurements	27	CA; IC; XRF	Local measurements (Gao et al., 2019)	27	GC-FID/MS
Waste treatment and	Sewage treatment	–	/			SPECIATE 4.4		
disposal source	Waste treatment	Landfill	/			SPECIATE 4.4		
		Composting	/			SPECIATE 4.4		
Agricultural source	Biomass burning	Field burning-Soybean	Local measurements (Tang et al., 2014)	1	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	1	GC-FID/MS
		Field burning-Rape	Local measurements (Tang et al., 2014)	2	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	2	GC-FID/MS
		Field burning-Rice stalk	Local measurements (Tang et al., 2014)	2	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	2	GC-FID/MS
		Field burning-Wheat stalk	Local measurements (Tang et al., 2014)	2	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	2	GC-FID/MS
		Field burning-Corn stalk	Local measurements (Tang et al., 2014)	2	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	2	GC-FID/MS
		Household stove-Soybean	Local measurements (Tang et al., 2014)	2	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	2	GC-FID/MS
		Household stove-Rape	Local measurements (Tang et al., 2014)	2	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	2	GC-FID/MS
		Household stove-Rice stalk	Local measurements (Tang et al., 2014)	2	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	2	GC-FID/MS
		Household stove-Straw	Local measurements (Tang et al., 2014)	2	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	2	GC-FID/MS
		Household stove-Corn stalk	Local measurements (Tang et al., 2014)	2	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	2	GC-FID/MS
		Household stove-Firewood	Local measurements (Tang et al., 2014)	1	CA; IC; ICPAES	Local measurements (Wang et al., 2014a)	1	GC-FID/MS

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5. Emissions for different cities and sources

Annual air pollutant emissions from each city in the YRD region is shown in Table S4. SO_2 emissions mainly came from Suzhou, Xuzhou and Changzhou in Jiangsu Province. The cities with the largest NO_x emissions were Shanghai, Suzhou and Xuzhou, followed by Ningbo and Hangzhou in Zhejiang Province. CO emissions from Suzhou and Nanjing were relatively higher, followed by Shanghai. VOC emissions came from Shanghai, Suzhou and Ningbo in turn. Xuzhou in Jiangsu Province had the largest PM_{10} and $PM_{2.5}$ emissions, followed by Hefei in Anhui Province. NH_3 emission distribution was quite different from the pollutants mentioned above. Yancheng, Xuzhou, and Nantong in Jiangsu Province had the largest emissions, followed by Fuyang and Suzhou in Anhui Province. Table S5 shows the air pollutant emissions from 10 major source categories and 55 subcategories. Among them, industrial process and solvent-use sources include 13 and 12 major sectors, respectively. The mobile sources include 14 categories, including 7 types of vehicles and 5 types of non-road machinery.

Table S4. Annual air pollutant emissions in each city of the YRD region in 2017.

Province	City	Annual air pollutant emissions (Gg/year)						
		SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3
Shanghai	Shanghai	57.2	224.7	1392.9	418.2	123.7	56.2	54.4
Jiangsu	Nanjing	51.7	131.2	1445.6	223.3	90.8	39.7	29.1
	Wuxi	42.0	94.6	1141.4	198.4	92.0	43.2	27.2
	Xuzhou	94.7	148.5	1683.2	148.8	207.0	94.1	164.3
	Changzhou	58.0	86.8	1313.7	153.1	118.9	44.8	26.7
	Suzhou	105.4	183.4	2257.3	263.5	149.7	77.3	34.5
	Nantong	40.4	81.2	2308.1	209.1	106.7	40.4	145.7
	Lianyungang	25.2	72.2	826.3	117.6	87.6	33.6	96.4
	Huaian	43.0	76.5	1978.3	105.9	109.7	34.5	104.1
	Yancheng	42.5	77.3	1094.7	132.6	127.8	47.6	214.3
	Yangzhou	24.8	52.1	930.1	139.5	104.8	34.2	51.6
	Zhenjiang	42.7	55.2	1004.8	119.8	71.5	30.1	23.0
	Taizhou	22.0	55.0	835.4	152.8	114.2	37.3	68.8
	Suqian	26.6	51.4	490.4	91.6	59.5	20.5	107.1
Zhejiang	Hangzhou	39.0	110.7	1204.2	177.7	99.4	39.5	56.1
	Ningbo	61.5	136.9	1546.4	347.9	124.8	57.7	35.5

	Wenzhou	14.8	62.9	465.1	124.0	62.4	20.0	38.6
	Jiaxing	33.4	68.9	1055.0	190.0	84.1	30.8	26.1
	Huzhou	52.5	46.1	466.7	120.6	69.0	31.2	27.0
	Shaoxing	27.1	56.8	646.9	148.3	67.4	24.6	42.1
	Jinhua	27.8	59.2	498.7	100.6	70.5	28.5	38.9
	Quzhou	41.0	46.2	534.5	60.4	50.5	24.8	42.1
	Zhoushan	5.5	15.8	97.6	47.6	21.8	8.6	3.1
	Taizhou	22.2	55.2	412.0	129.5	84.9	29.6	31.6
	Lishui	13.8	17.9	109.0	36.9	40.5	12.3	21.6
Anhui	Hefei	21.5	98.7	907.1	149.1	135.0	55.1	73.1
	Wuhu	39.4	85.2	815.3	82.9	99.0	43.5	34.3
	Bengbu	15.8	40.3	599.4	63.5	116.1	40.7	79.2
	Huainan	19.6	48.6	848.3	27.2	74.3	41.5	61.9
	Ma’anshan	26.5	42.9	599.5	28.8	75.8	36.7	15.7
	Huaibei	36.9	45.2	4437.3	37.5	74.3	44.1	21.0
	Tongling	44.3	58.3	598.8	26.2	72.1	40.8	14.9
	Anqing	41.7	48.0	671.1	78.5	86.9	37.0	62.4
	Huangshan	6.5	8.7	134.8	17.1	22.8	7.0	21.5
	Chuzhou	19.3	58.8	590.3	81.1	107.2	46.4	90.5
	Fuyang	33.8	78.1	524.2	77.0	133.0	63.1	145.7
	Suzhou	35.2	75.1	594.9	71.5	106.2	53.4	132.3
	Lu’an	18.0	54.0	323.2	51.2	81.9	35.5	73.8
	Bozhou	16.4	48.6	318.8	49.6	75.6	35.5	80.5
	Chizhou	19.9	32.0	338.8	22.4	73.3	28.0	17.5
	Xuancheng	27.4	46.7	446.1	45.9	81.8	33.3	32.9

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Table S5. Annual air pollutant emissions from different source in the YRD region in 2017.

1st level	2nd level	SO_2	NO_x	CO	NMVOCs	PM_{10}	$PM_{2.5}$	NH_3
Power plants	Power plants	247.3	446.5	1444.0	12.1	156.0	105.5	11.4
Boilers	Boilers	756.1	418.0	28259.7	9.5	62.5	36.6	1.5
Industrial process sources	Mining	14.5	18.9	72.8	1.8	111.2	65.2	0.5
	Agricultural products processing	0.3	0.1	0.3	62.7	97.7	70.5	-
	Food manufacturing	0.1	-	0.1	0.6	5.6	3.9	-
	Beverage manufacturing	0.1	-	0.1	104.1	0.1	-	-
	Papermaking	17.7	0.4	30.7	8.7	10.0	8.0	-
	Petroleum refining	9.7	4.5	629.8	156.4	23.1	22.3	2.0
	Coking	34.7	17.6	241.3	1.3	17.6	13.2	0.1
	Chemical manufacturing	93.6	39.6	474.1	801.2	21.1	15.2	45.0
	Rubber and plastic manufacturing	0.6	0.4	1.0	254.7	0.1	0.1	-
	Non-metallic mineral manufacturing	69.6	240.5	506.4	191.4	606.5	338.2	-
	Ferrous metal manufacturing	77.5	105.2	383.5	32.6	91.2	69.9	0.3
	Non-ferrous metal manufacturing	20.7	0.8	0.9	1.6	107.3	77.2	-
	Other miscellaneous sources	6.7	4.0	19.2	55.4	4.4	2.8	-
Industrial solvent-use sources	Textile	1.5	1.0	2.1	102.4	0.3	0.2	-
	Leather tanning	-	-	-	0.9	-	-	-
	Furniture and wood manufacturing	-	-	-	363.4	-	-	-
	Package and printing	-	-	-	51.0	-	-	-
	Pharmaceutical manufacturing	-	-	0.1	103.2	-	-	-
	Shoemaking	-	-	-	15.8	-	-	-
	Metal products	0.2	0.1	0.1	77.6	40.7	24.4	-
	Machinery manufacturing	0.3	0.8	1.0	135.5	19.4	13.2	-
	Railway equipment	0.1	0.1	0.1	5.1	0.2	0.1	-
	Auto manufacturing	0.2	-	-	71.0	1.0	0.6	-
	Shipbuilding	-	-	-	20.8	0.2	0.2	-
	Appliance manufacturing	-	-	-	272.2	-	-	-
	Electronic equipment	0.3	0.1	0.2	100.8	0.1	-	-
Mobile sources	Light-duty vehicles	0.0	216.0	2694.3	434.9	17.7	17.4	28.2
	Light-duty trucks	0.0	48.7	134.3	19.4	8.5	7.7	0.8
	Heavy-duty vehicles	0.0	103.5	189.8	32.5	9.8	8.8	0.3
	Heavy-duty trucks	0.0	571.7	201.4	63.3	49.8	44.9	0.0
	Taxi	0.0	10.3	85.1	24.6	0.3	0.3	0.8
	Bus	0.0	92.9	111.0	26.7	4.1	3.7	0.1
	Motorcycle	0.0	5.4	175.0	228.9	0.8	0.8	1.1
	Construction machinery	3.0	248.4	70.5	20.0	10.7	10.2	0.0
	Port machinery	0.2	13.7	6.3	1.3	0.6	0.5	0.0
	Factory machinery	0.5	48.8	19.6	4.7	2.7	2.5	0.0
	Agricultural machinery	2.3	186.0	693.3	85.4	15.0	14.3	0.0

	Ground handling equipment	0.1	3.7	2.4	0.4	0.1	0.1	0.0
	Marine	114.9	298.8	21.3	7.8	15.9	14.6	0.1
	Aviation aircraft	0.8	11.9	7.3	1.3	0.1	0.1	0.0
Dust sources	Construction dust	-	-	-	-	1480.8	302.2	-
	Road dust	-	-	-	-	607.1	146.9	-
Oil storage and transportation sources	Oil depot	-	-	-	251.1	-	-	-
	Gas station	-	-	-	44.5	-	-	-
Residential sources	Human excretion	58.9	28.1	438.8	15.1	54.0	48.3	3.4
	Residential combustion	-	-	-	435.2	-	-	-
	Residential solvent-use	-	-	-	20.5	10.2	8.2	-
	Catering	-	-	-	-	-	-	82.2
Waste treatment and disposal sources	Sewage treatment	-	-	-	13.0	-	-	37.7
	Waste treatment	3.4	30.1	1.2	8.7	1.4	1.4	17.3
Agricultural sources	Biomass burning	16.6	17.7	1587.9	122.1	104.6	97.3	5.4
	Fertilizer application	-	-	-	-	-	-	32.5
	Soil background	-	-	-	-	-	-	728.6
	Livestock and poultry breeding	-	-	-	-	-	-	1467.6
	Total	1552.5	3234.5	38507.1	4875.2	3770.5	1597.5	2466.7

6. Model validation

We used the Community Modeling and Analysis System (CMAQ version 5.3) to simulate the concentrations of SO_2, NO_2, $PM_{2.5}$, PM_{10}, O_3, and CO in the YRD region in January and July 2017, then compared with the observation data in each city of the region. Figure S1 shows the model domain and the locations of observation data for meteorology and $PM_{2.5}$ chemical composition. Simulations were conducted for three nested grids with horizontal resolution of 36 km (D1), 12km (D2) and 4km(D3), respectively. D1 covers most of China and the surrounding countries including Japan and South Korea; D2 covers eastern China and D3 covers the entire YRD region and its surrounding land and waters. Meteorological fields were provided by the Weather Research and Forecasting (WRF version 3.7) model with 27 vertical layers extending to the tropopause (100hpa). WRF initial and boundary conditions (ICs, BCs) are based on the 1° × 1° reanalysis data from the National Centers for Environmental Prediction Final Analysis (NCEP-FNL). Physical options used in the WRF simulation are listed in Table S1. The emission inventory developed in this study was used to produce the emission system in the YRD region while emission beyond YRD was supplied by

Multiresolution Emission Inventory for China (MEIC-2016) (http://www.meicmodel.org) and the Model Inter-Comparison Study (MIX) emission inventory for 2010 (Li et al., 2017). Biogenic emissions are estimated by Model of Emissions of Gases and Aerosols from Nature (MEGAN) v2.1 using WRF meteorology predictions. The Sparse Matrix Operator Kernel Emissions (SMOKE, https://www.cmascenter.org/smoke) model is applied to process emissions for input to CMAQ. CMAQ version 5.3.0 (https://www.cmascenter.org/cmaq/) was used to simulate atmospheric pollutants concentrations. ICs and BCs of D1 domain are based on a Model For Ozone And Related Chemical Tracers (MOZART) global simulation (https://www.acom.ucar.edu/wrf-chem/mozart.shtml). For the inner D2 and D3 domain, ICs and BCs are extracted from the simulation results of the outer domains. Options selected for the CMAQ simulations include the CB6r3 gas phase chemistry, the AERO6 aerosol scheme, the Regional Acid Deposition Model (RADM) model aqueous phase chemistry, ISORROPIA inorganic particulate thermodynamics, and SOAP secondary organic aerosol scheme.

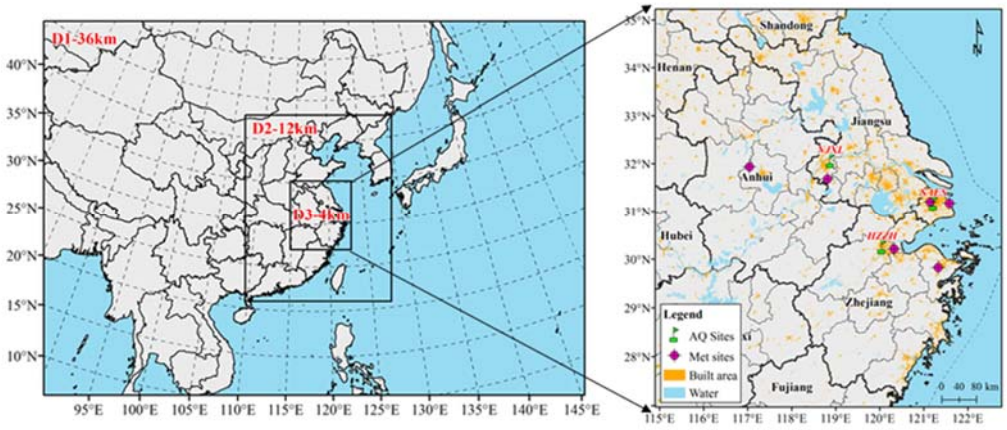

Figure S1. Nested Modeling domain (left) and observation sites (right) for model validation.

Table S6. Parameterization scheme and inputs for the WRF and CMAQ model.

Model	Option	Configuration/Data source	Reference
WRF	Version	WRF-v3.9.1	https://www2.mmm.ucar.edu/wrf/
	IC/BC condition	NCEP FNL1°×1°	https://rda.ucar.edu/datasets/ds083.2/
	Microphysical Process	Purdue Lin Scheme	Lin, 1983
	Cumulus Convective Scheme	Grell-3 Scheme	Grell and Dévényi, 2002
	Road Process Scheme	Noah Scheme	Ek, 2003

	Boundary Layer Scheme	Yonsei University (YSU) Scheme	Hong, 2006
	Long-wave and Short-wave radiation scheme	RRTM and Goddard radiation Scheme	Mlawer et al., 1997; Chou and Suarez, 1999
CMAQ	Version	CMAQ-v5.3.0	https://www.cmascenter.org/cmaq/
	Domain	Three nested grid(36/12/4km)	-
	Gas Chemical Mechanism	CB6r3	http://www.camx.com/files/udaq_snowchem_final_6aug15.pdf
	Aerosol Chemical Mechanism	AERO6	https://github.com/USEPA/CMAQ/blob/master/CCTM/src/MECHS/README.md
	Anthropogenic emission inventory	MIX(2010) and MEIC(2016) emissions for 36km,12km and area around the YRD in 4km domain	Li et al., 2017 http://www.meicmodel.org/
	Biogenic emission inventory	MEGAN-v2.10	;https://bai.ess.uci.edu/megan; Liu et al., 2018
	Emission processor	SMOKE-v46	https://www.cmascenter.org/smoke/

Table S7 compares the average concentration of observation and simulation data in each city of the YRD region in January and July 2017 and shows the statistical results of model performance. We used Normalized Mean Bias (NMB), Normalized Mean Error (NME), Mean Fractional Bias (MFB) and Mean Fractional Error (MFE) to characterize the deviation of simulation concentrations from measured results. For NMB and MFB, negative numbers indicate that the simulation result is lower, while positive numbers are the opposite. The smaller the absolute value of these four statistics, the higher the accuracy.

Table S7. The statistical results of model performance in each city of the YRD region in January and July 2017.

(a) SO_2

Province	City	Jan.									Jul.								
		Data pairs	Obs. (μg/m^3)	Sim. (μg/m^3)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R	Data pairs	Obs. (μg/m^3)	Sim. (μg/m^3)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R
Shanghai	Shanghai	624	18.0	10.2	-43.5	51.2	-69.0	74.3	0.6	0.5	741	11.3	7.0	-37.6	60.1	-65.3	83.7	0.4	0.1
Jiangsu	Nanjing	613	16.8	16.5	-1.8	41.2	-8.6	42.8	0.6	0.4	722	6.0	5.2	-13.1	93.5	-39.0	100.8	0.2	-0.2
	Wuxi	618	15.4	15.5	0.8	38.4	-5.4	39.1	0.7	0.5	740	8.0	5.9	-26.5	73.8	-50.6	87.9	0.2	-0.3
	Xuzhou	606	33.9	36.9	8.9	47.8	-2.4	44.1	0.6	0.4	740	13.0	16.0	23.4	76.5	-8.5	67.9	0.3	0.1
	Changzhou	622	16.3	18.8	15.5	44.9	7.3	40.7	0.6	0.4	701	16.2	7.6	-53.0	61.4	-86.2	93.1	0.5	0.2
	Suzhou	623	17.1	14.2	-17.0	37.7	-29.7	46.8	0.7	0.6	618	8.5	7.9	-7.2	58.4	-23.6	63.7	0.4	0.1
	Nantong	619	13.1	12.7	-3.4	44.3	-13.6	44.7	0.8	0.6	679	16.6	14.7	-11.3	54.0	-30.2	64.0	0.6	0.4
	Lianyungang	601	31.3	12.5	-60.2	61.3	-92.4	93.7	0.5	0.5	741	5.5	3.0	-45.5	65.6	-79.6	96.1	0.3	-0.1
	Huaian	617	17.4	17.0	-2.1	58.7	-11.3	59.3	0.5	0.3	737	9.6	11.9	24.4	86.3	-9.0	78.3	0.4	0.2
	Yancheng	617	17.2	9.9	-42.2	51.1	-67.4	74.5	0.6	0.5	738	8.0	5.2	-35.4	53.1	-63.5	76.9	0.4	0.3
	Yangzhou	624	14.9	14.0	-6.0	41.6	-16.3	44.6	0.7	0.5	691	18.1	8.1	-54.9	62.1	-89.4	96.0	0.5	0.3
	Zhenjiang	621	12.0	19.9	65.9	83.3	43.9	57.7	0.6	0.5	741	16.9	12.7	-25.1	58.2	-38.4	70.2	0.5	0.1

	Taizhou	500	14.4	10.8	-24.9	47.7	-45.1	61.7	0.6	0.4	740	12.4	8.9	-28.2	72.6	-28.8	94.0	0.4	0.1
	Suqian	622	20.1	14.8	-26.4	44.4	-40.3	56.2	0.6	0.3	66	8.1	3.9	-51.9	54.4	-73.3	76.9	0.3	0.2
	Hangzhou	624	13.0	12.4	-4.3	39.5	-11.9	42.5	0.6	0.4	740	8.3	4.4	-46.9	55.6	-72.0	77.8	0.5	0.4
	Ningbo	623	11.5	16.2	41.0	71.3	8.9	47.4	0.4	0.4	740	8.3	8.4	0.9	64.2	-29.9	62.5	0.2	0.3
	Wenzhou	575	6.6	8.0	21.6	65.6	24.9	64.3	0.6	0.4	741	10.4	6.0	-42.7	52.9	-67.8	77.7	0.5	0.4
	Jiaxing	597	11.1	14.3	28.2	49.5	14.2	43.2	0.7	0.6	704	7.8	8.0	2.2	50.8	-7.0	57.2	0.7	0.5
	Huzhou	621	14.2	12.5	-12.2	44.6	-25.0	51.4	0.6	0.4	731	7.1	3.6	-49.8	65.6	-93.2	104.2	0.5	0.4
Zhejiang	Shaoxing	623	12.1	15.1	24.5	56.7	15.2	49.7	0.5	0.3	678	12.1	8.1	-32.8	52.1	-43.2	66.2	0.5	0.2
	Jinhua	623	12.4	9.5	-23.3	46.7	-25.3	58.7	0.6	0.4	734	7.4	3.7	-50.0	60.5	-76.2	85.9	0.5	0.3
	Quzhou	622	12.0	21.0	75.8	108.0	45.7	68.4	0.3	0.1	722	15.5	27.4	76.9	132.5	29.2	90.2	0.4	0.2
	Zhoushan	614	11.3	5.8	-48.2	53.5	-80.7	84.5	0.6	0.7	741	7.6	5.0	-33.7	48.9	-55.5	65.3	0.6	0.5
	Taizhou	622	8.5	8.5	0.7	57.2	5.1	59.9	0.6	0.3	741	5.6	4.6	-18.5	44.5	-24.7	54.4	0.7	0.5
	Lishui	621	9.3	6.2	-32.9	50.4	-54.2	69.3	0.5	0.3	712	7.0	1.5	-78.1	78.3	-136.3	136.4	0.4	0.3
	Hefei	624	18.1	14.8	-18.2	41.7	-21.7	46.5	0.6	0.3	732	5.1	4.3	-15.6	53.9	-24.7	61.8	0.5	0.2
	Wuhu	614	20.6	15.4	-25.3	48.6	-35.4	56.0	0.4	0.1	737	11.5	9.4	-18.2	60.1	-25.7	71.0	0.6	0.3
	Bengbu	618	17.4	14.5	-16.8	55.7	-19.8	58.5	0.5	0.1	739	8.5	4.5	-47.3	56.3	-74.4	84.4	0.5	0.2
	Huainan	619	22.3	20.3	-9.1	39.8	-12.4	42.6	0.6	0.3	739	7.0	5.5	-21.5	48.7	-37.8	58.6	0.5	0.3
	Maanshan	616	17.7	23.2	31.2	72.3	27.5	60.3	0.4	0.1	733	9.8	10.3	5.5	79.7	9.9	82.6	0.5	0.3
	Huaibei	614	24.6	23.1	-6.1	39.5	-9.3	41.2	0.7	0.5	737	7.8	9.2	18.3	68.2	-7.6	68.3	0.5	0.3
	Tongling	564	23.5	23.2	-1.3	62.1	0.9	60.2	0.5	0.2	731	19.2	9.6	-49.9	63.3	-72.4	87.3	0.5	0.2
	Anqing	610	20.7	23.6	13.8	60.8	9.9	53.9	0.4	0.1	739	13.0	12.8	-1.7	71.8	-19.5	71.6	0.2	-0.2
Anhui	Huangshan	619	11.7	9.8	-16.4	56.6	-16.5	59.9	0.4	0.0	739	18.3	2.0	-89.1	89.1	-159.5	159.5	0.3	0.0
	Chuzhou	621	14.7	14.3	-2.7	55.5	-14.8	57.5	0.5	0.2	737	12.3	5.0	-59.2	67.5	-87.4	97.0	0.4	0.0
	Fuyang	603	15.0	27.2	81.4	101.1	45.6	63.3	0.3	0.2	739	13.4	12.0	-10.6	72.1	-31.9	79.5	0.4	0.0
	Suzhou	591	24.9	19.9	-20.4	52.5	-15.6	57.4	0.6	0.3	703	14.8	4.7	-68.3	71.8	-98.2	104.0	0.4	0.1
	Lu'an	622	16.5	13.5	-18.2	46.9	-27.2	54.5	0.5	0.2	738	8.4	3.2	-62.0	64.4	-93.5	96.2	0.4	0.0
	Bozhou	615	29.8	19.1	-35.8	51.4	-48.3	64.8	0.5	0.2	723	9.4	4.0	-57.3	59.7	-89.4	91.8	0.4	0.2
	Chizhou	604	23.8	19.6	-17.7	50.6	-23.8	54.6	0.5	0.2	739	18.9	3.8	-79.8	81.3	-129.6	131.6	0.4	-0.1
	Xuancheng	612	21.0	16.0	-24.0	46.3	-34.9	56.1	0.3	-0.1	741	14.1	2.9	-79.5	80.4	-130.7	132.2	0.4	0.2

252 (b) NO_2

Province	City	Jan									Jul								
		Data pairs	Obs. ($\mu g/m^3$)	Sim. ($\mu g/m^3$)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R	Data pairs	Obs. ($\mu g/m^3$)	Sim. ($\mu g/m^3$)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R
Shanghai	Shanghai	624	44.7	50.6	13.2	38.1	11.9	35.8	0.7	0.5	738	30.1	42.7	41.7	63.7	24.9	47.1	0.6	0.5
	Nanjing	613	36.5	45.6	25.0	48.6	19.7	45.4	0.7	0.5	723	25.7	24.6	-4.2	62.1	-18.2	64.8	0.6	0.3
	Wuxi	615	58.5	51.6	-11.8	31.3	-9.1	34.6	0.7	0.6	740	26.7	31.4	17.7	56.6	6.5	45.9	0.6	0.4
Jiangsu	Xuzhou	620	54.2	49.8	-8.1	28.5	-7.3	31.2	0.8	0.6	740	22.0	24.6	11.7	46.8	15.1	44.1	0.7	0.5
	Changzhou	622	42.5	50.9	19.7	41.6	19.2	42.3	0.7	0.5	704	26.3	29.7	13.1	59.5	2.1	52.2	0.6	0.3
	Suzhou	623	50.3	50.6	0.6	31.6	0.8	33.6	0.8	0.6	618	30.3	33.4	10.5	56.1	-1.5	51.5	0.5	0.2

	Nantong	619	32.2	36.2	12.5	43.5	9.7	42.4	0.8	0.6	678	45.5	43.5	-4.4	51.5	-9.0	55.5	0.6	0.4
	Lianyungang	621	39.7	34.0	-14.4	41.4	-8.7	46.1	0.7	0.5	741	17.4	18.2	4.5	50.5	-4.9	46.8	0.5	0.3
	Huaian	620	29.8	31.9	6.9	45.4	2.2	42.0	0.7	0.5	738	23.3	33.0	41.6	66.7	29.8	53.0	0.5	0.3
	Yancheng	617	32.8	20.8	-36.7	50.6	-48.2	66.4	0.7	0.5	739	21.7	16.9	-22.0	48.9	-42.6	62.1	0.6	0.4
	Yangzhou	619	43.8	34.2	-22.0	38.4	-28.5	43.9	0.7	0.6	689	29.1	28.1	-3.5	49.5	-19.6	53.5	0.7	0.5
	Zhenjiang	621	42.6	38.4	-9.9	35.3	-14.6	39.4	0.8	0.6	740	29.3	30.5	4.2	52.2	4.6	52.5	0.6	0.4
	Taizhou	500	27.1	28.5	5.2	43.9	-0.3	40.2	0.7	0.5	740	24.8	29.4	18.7	67.4	5.0	58.6	0.5	0.3
	Suqian	622	39.1	36.0	-8.1	36.8	-11.6	39.8	0.7	0.5	66	25.5	20.8	-18.2	46.2	-29.0	54.9	0.6	0.4
Zhejiang	Hangzhou	624	44.6	47.5	6.7	38.1	9.3	39.8	0.7	0.5	740	26.6	32.5	22.1	56.4	14.8	46.7	0.6	0.3
	Ningbo	623	41.8	40.5	-3.2	37.5	-3.5	40.5	0.8	0.6	740	31.3	34.8	11.1	43.1	11.4	38.3	0.7	0.6
	Wenzhou	574	31.1	30.9	-0.7	42.8	-1.1	42.5	0.6	0.4	741	25.9	29.5	14.3	44.4	3.8	38.2	0.6	0.5
	Jiaxing	597	35.8	38.0	6.3	43.8	11.6	44.1	0.7	0.4	704	26.4	26.0	-1.8	48.6	-8.7	48.5	0.7	0.5
	Huzhou	621	37.1	29.7	-20.0	46.2	-22.4	52.4	0.6	0.4	731	27.4	10.7	-61.0	70.4	-92.1	103.8	0.4	0.1
	Shaoxing	623	45.7	36.9	-19.2	36.7	-20.3	42.9	0.7	0.5	670	19.2	16.9	-12.0	40.0	-17.9	41.3	0.6	0.4
	Jinhua	623	32.8	29.7	-9.2	37.2	-8.1	41.4	0.7	0.5	732	19.0	13.5	-29.1	52.0	-45.0	61.9	0.5	0.3
	Quzhou	623	34.7	46.6	34.2	66.2	21.2	52.6	0.3	0.1	730	23.9	45.2	89.1	116.9	51.7	76.3	0.3	-0.1
	Zhoushan	614	13.0	15.7	20.7	54.3	14.5	48.6	0.7	0.6	741	15.4	18.6	21.1	51.3	12.2	43.0	0.7	0.5
	Taizhou	622	24.9	27.2	9.5	45.5	11.0	42.7	0.6	0.4	741	11.9	17.3	45.2	66.4	30.9	47.2	0.7	0.6
	Lishui	621	21.0	13.7	-34.6	46.7	-36.8	57.7	0.6	0.5	712	14.6	7.5	-48.5	51.7	-60.7	65.4	0.6	0.4
Anhui	Hefei	624	44.8	48.0	7.3	35.0	11.4	35.6	0.7	0.6	732	30.2	32.4	7.1	39.3	3.6	36.1	0.7	0.5
	Wuhu	613	42.6	32.7	-23.3	44.2	-19.8	48.4	0.7	0.5	740	31.4	23.1	-26.5	49.7	-23.9	57.2	0.7	0.5
	Bengbu	621	34.6	31.5	-8.9	45.7	-0.5	52.4	0.7	0.5	739	20.7	15.7	-24.3	46.9	-30.6	56.8	0.7	0.5
	Huainan	622	25.8	40.0	54.6	70.0	46.9	57.9	0.6	0.4	739	17.6	17.3	-1.9	52.9	-8.4	50.1	0.4	0.2
	Maanshan	616	36.0	44.8	24.5	49.4	25.0	46.8	0.6	0.4	737	23.5	23.4	-0.5	53.3	-1.8	51.9	0.6	0.3
	Huaibei	616	57.9	42.0	-27.4	40.0	-29.9	51.6	0.6	0.5	737	23.1	22.0	-5.0	43.1	-5.7	42.4	0.6	0.4
	Tongling	624	40.0	35.4	-11.5	42.6	-10.1	47.4	0.7	0.4	741	31.1	14.2	-54.4	60.0	-70.1	77.6	0.6	0.5
	Anqing	619	40.8	30.1	-26.2	41.4	-24.1	44.6	0.6	0.4	741	29.3	16.4	-43.9	56.8	-40.4	62.2	0.5	0.3
	Huangshan	622	18.0	13.0	-28.0	43.2	-33.4	49.2	0.5	0.3	739	20.7	6.9	-66.5	66.7	-103.9	104.1	0.4	0.3
	Chuzhou	619	38.5	32.5	-15.6	41.7	-21.9	47.2	0.7	0.5	739	23.4	15.3	-34.6	54.8	-45.5	62.3	0.5	0.3
	Fuyang	603	40.1	42.1	5.2	33.8	2.7	33.4	0.7	0.5	739	21.3	18.0	-15.4	39.5	-21.1	43.1	0.6	0.3
	Suzhou	622	43.9	41.4	-5.8	35.9	0.0	38.7	0.8	0.6	718	23.9	22.6	-5.3	39.6	-5.4	40.5	0.7	0.5
	Liuan	623	39.7	28.2	-28.9	40.9	-37.1	50.7	0.6	0.5	737	22.1	14.4	-34.7	49.8	-50.9	66.9	0.5	0.3
	Bozhou	618	30.6	37.3	21.9	47.1	25.8	47.6	0.7	0.6	723	12.0	13.3	10.1	50.7	4.9	47.2	0.6	0.3
	Chizhou	622	39.2	27.1	-30.7	44.8	-39.3	53.9	0.6	0.4	739	21.9	8.5	-61.1	62.7	-88.1	89.9	0.4	0.3
	Xuancheng	612	22.8	26.8	17.7	60.9	12.8	54.1	0.6	0.3	741	25.7	11.8	-54.3	63.8	-74.0	91.0	0.4	0.0

253 (c) $PM_{2.5}$

Province	City	Jan									Jul								
		Data pairs	Obs. (μg/m^3)	Sim. (μg/m^3)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R	Data pairs	Obs. (μg/m^3)	Sim (μg/m^3)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R

Shanghai	Shanghai	624	61.4	45.6	-25.7	37.4	-46.5	61.7	0.7	0.6	677	90.5	62.4	-31.0	40.4	-57.3	71.3	0.8	0.8
	Nanjing	613	63.3	40.9	-35.4	49.7	-55.3	76.5	0.6	0.4	713	85.5	81.8	-4.3	43.4	-10.1	53.1	0.8	0.6
	Wuxi	618	39.6	39.3	-0.8	46.1	-21.8	66.6	0.8	0.6	729	87.8	72.7	-17.1	34.1	-25.9	52.0	0.9	0.8
	Xuzhou	622	30.0	33.1	10.4	51.6	-13.0	75.6	0.8	0.7	740	84.9	93.8	10.5	35.0	18.1	40.0	0.8	0.7
	Changzhou	622	40.9	39.8	-2.6	52.1	-30.2	73.9	0.7	0.5	699	81.1	71.3	-12.0	38.4	-20.6	56.3	0.8	0.7
	Suzhou	623	41.8	41.5	-0.6	47.4	-29.5	64.2	0.7	0.6	616	85.4	74.6	-12.6	38.3	-30.1	55.5	0.8	0.7
	Nantong	619	62.4	53.7	-13.9	30.8	-28.0	46.5	0.7	0.6	657	85.1	72.7	-14.6	37.0	-33.4	62.1	0.9	0.8
Jiangsu	Lianyungang	620	47.0	49.7	5.9	38.9	12.0	52.8	0.8	0.6	736	65.9	94.1	42.8	53.4	36.3	47.6	0.7	0.6
	Huaian	621	46.9	52.7	12.3	38.9	8.4	48.5	0.7	0.6	717	72.2	73.7	2.1	40.1	10.8	49.2	0.8	0.6
	Yancheng	611	57.2	64.8	13.4	34.5	12.5	41.5	0.7	0.5	739	60.0	81.5	36.0	52.5	32.5	50.4	0.7	0.6
	Yangzhou	624	49.7	52.7	6.0	35.8	-2.9	51.1	0.8	0.6	646	82.1	72.4	-11.8	42.0	-13.2	61.6	0.8	0.7
	Zhenjiang	621	49.8	49.8	0.0	36.6	-15.0	54.1	0.8	0.6	738	64.9	70.5	8.6	41.6	8.5	59.1	0.9	0.8
	Taizhou	499	51.1	59.1	15.6	35.5	4.6	40.0	0.7	0.5	728	77.4	73.8	-4.7	39.9	-14.4	57.2	0.9	0.7
	Suqian	612	42.7	47.6	11.4	45.0	1.7	56.7	0.7	0.6	66	66.3	71.6	8.0	30.8	13.1	34.6	0.9	0.7
	Hangzhou	624	38.2	48.7	27.5	63.9	15.0	73.1	0.7	0.6	700	70.1	62.1	-11.4	45.8	-5.5	61.9	0.8	0.7
	Ningbo	623	50.6	60.4	19.3	40.6	19.6	51.8	0.8	0.6	717	69.7	59.6	-14.4	34.0	-16.3	48.0	0.9	0.8
	Wenzhou	575	49.1	69.2	41.0	56.9	39.9	57.4	0.7	0.6	725	61.3	53.1	-13.4	36.8	-12.9	47.4	0.9	0.8
	Jiaxing	574	43.9	55.2	25.8	52.8	24.2	58.7	0.7	0.5	689	91.0	79.1	-13.2	29.7	-12.9	46.8	0.9	0.8
	Huzhou	621	45.4	61.1	34.7	59.8	38.1	64.3	0.7	0.4	717	68.6	78.8	14.8	49.6	42.6	67.0	0.8	0.8
Zhejiang	Shaoxing	623	37.8	58.2	54.1	71.7	43.1	71.1	0.7	0.6	649	90.5	76.0	-16.0	28.3	-18.0	35.3	0.9	0.8
	Jinhua	614	36.0	65.6	82.1	92.4	64.0	76.5	0.6	0.6	722	73.9	64.4	-12.8	32.8	-4.8	42.3	0.9	0.8
	Quzhou	623	39.3	51.6	31.5	64.2	28.2	67.4	0.7	0.4	726	60.1	34.7	-42.2	59.4	-31.0	80.5	0.6	0.6
	Zhoushan	614	76.4	84.6	10.8	23.7	11.3	25.7	0.7	0.6	739	61.9	51.8	-16.2	33.9	-23.2	43.4	0.8	0.7
	Taizhou	622	58.5	70.6	20.7	42.2	22.8	45.5	0.7	0.5	741	63.6	59.0	-7.3	32.0	-14.8	41.1	0.9	0.8
	Lishui	621	53.8	84.9	57.7	70.2	54.3	63.7	0.6	0.5	712	65.8	69.3	5.4	36.9	24.7	47.8	0.8	0.8
	Hefei	624	39.3	38.1	-3.0	48.0	-19.2	66.0	0.8	0.6	719	86.3	75.4	-12.6	37.5	-10.9	48.3	0.8	0.7
	Wuhu	616	54.3	53.5	-1.3	45.2	-16.1	55.2	0.5	0.3	667	76.9	72.2	-6.1	45.2	17.0	61.1	0.8	0.7
	Bengbu	621	46.9	52.2	11.3	44.7	7.7	56.9	0.8	0.6	739	76.9	89.4	16.3	33.9	20.2	37.4	0.9	0.8
	Huainan	622	44.5	44.8	0.6	46.4	0.0	60.2	0.7	0.5	736	74.4	84.0	12.9	36.7	18.5	41.2	0.8	0.6
	Maanshan	604	39.1	42.7	9.1	52.8	-4.7	64.9	0.7	0.5	715	79.3	79.7	0.5	39.3	14.5	51.9	0.9	0.8
	Huaibei	618	35.0	39.9	14.2	52.9	4.0	67.1	0.8	0.6	737	78.5	95.3	21.4	40.1	27.1	43.7	0.8	0.7
	Tongling	624	48.1	53.9	12.1	56.3	4.0	63.8	0.6	0.4	741	67.4	82.5	22.4	44.9	27.6	46.5	0.8	0.6
Anhui	Anqing	618	54.2	60.7	12.0	49.6	13.5	52.3	0.6	0.3	737	68.1	80.7	18.6	36.7	20.9	38.2	0.8	0.7
	Huangshan	621	62.9	85.8	36.3	50.1	31.3	44.3	0.6	0.4	739	52.8	69.6	31.8	42.9	34.7	41.7	0.8	0.7
	Chuzhou	621	72.6	52.3	-27.9	40.7	-42.2	58.7	0.6	0.4	739	88.0	89.5	1.7	28.7	-3.9	35.1	0.8	0.7
	Fuyang	602	34.5	40.9	18.4	55.2	4.7	66.1	0.8	0.6	739	59.4	84.4	42.0	47.8	40.0	46.3	0.8	0.7
	Suzhou	622	38.8	40.7	4.8	42.7	-11.5	59.9	0.8	0.7	731	85.8	86.0	0.2	31.3	5.6	36.6	0.8	0.7
	Liuan	624	49.3	55.2	12.1	49.1	11.1	55.7	0.7	0.5	736	70.1	83.7	19.3	38.7	23.7	40.7	0.8	0.6
	Bozhou	618	42.9	43.0	0.3	38.8	-13.2	51.6	0.8	0.7	722	88.8	97.6	9.9	31.0	14.0	33.4	0.8	0.6
	Chizhou	621	40.6	63.1	55.3	72.2	40.7	63.7	0.6	0.4	739	79.9	80.3	0.5	24.5	0.4	26.4	0.8	0.7

	Xuancheng	612	37.6	62.7	66.6	92.8	37.0	67.8	0.3	0.0	741	64.8	71.1	9.6	33.4	13.6	37.0	0.8	0.7

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Province	City	Jan									Jul								
		Data pairs	Obs. ($\mu g/m^3$)	Sim. ($\mu g/m^3$)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R	Data pairs	Obs. ($\mu g/m^3$)	Sim. ($\mu g/m^3$)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R
Shanghai	Shanghai	616	41.6	36.6	-12.0	37.7	-4.7	37.8	0.8	0.6	732	30.7	30.2	-1.8	40.5	-10.2	40.9	0.7	0.6
	Nanjing	611	46.4	46.3	-0.2	43.2	4.3	47.7	0.7	0.5	628	18.8	22.8	21.5	54.5	17.6	54.1	0.7	0.6
	Wuxi	617	48.2	44.5	-7.7	40.0	-6.5	42.1	0.7	0.5	734	25.0	24.9	-0.4	51.8	-9.6	51.6	0.7	0.5
	Xuzhou	597	83.4	61.7	-26.0	35.6	-29.2	40.5	0.7	0.6	735	34.3	27.1	-21.0	45.1	-21.8	51.9	0.6	0.4
	Changzhou	620	58.0	48.2	-17.0	37.6	-16.4	42.8	0.7	0.5	704	28.3	24.7	-12.8	42.3	-18.5	48.4	0.8	0.6
	Suzhou	622	53.2	45.2	-15.0	36.7	-9.1	39.2	0.8	0.6	617	23.7	30.3	28.0	57.9	10.6	43.5	0.5	0.5
	Nantong	618	53.4	38.3	-28.3	38.7	-27.8	45.7	0.8	0.7	681	34.8	30.4	-12.7	38.6	-15.6	43.4	0.7	0.5
Jiangsu	Lianyungang	618	52.8	41.8	-20.8	41.6	-23.3	48.2	0.7	0.6	741	33.5	17.7	-47.2	54.9	-59.3	70.5	0.5	0.3
	Huaian	621	58.6	48.3	-17.6	44.3	-13.4	51.1	0.7	0.5	737	33.9	24.6	-27.5	40.0	-38.9	50.8	0.5	0.3
	Yancheng	612	45.8	34.5	-24.6	47.1	-18.1	53.4	0.7	0.6	730	28.0	23.2	-17.2	50.1	-25.0	57.5	0.6	0.4
	Yangzhou	612	63.4	49.0	-22.8	39.2	-19.8	46.6	0.7	0.6	691	34.7	26.7	-23.2	39.3	-33.1	47.5	0.7	0.6
	Zhenjiang	621	58.2	43.5	-25.3	35.1	-30.1	41.3	0.7	0.6	741	36.2	24.3	-32.7	44.1	-47.1	58.5	0.7	0.5
	Taizhou	494	53.0	37.8	-28.8	42.2	-29.7	48.2	0.7	0.5	736	32.7	28.9	-11.6	43.1	-16.9	47.1	0.6	0.4
	Suqian	622	60.5	47.5	-21.4	37.5	-22.0	44.4	0.8	0.7	65	28.4	16.1	-43.4	48.0	-51.0	57.5	0.4	0.0
	Hangzhou	624	51.5	43.4	-15.7	39.3	-16.8	43.4	0.7	0.5	740	26.3	19.7	-25.2	33.8	-33.1	42.6	0.8	0.8
	Ningbo	623	40.0	36.6	-8.5	45.9	-9.3	49.7	0.7	0.6	740	26.2	21.9	-16.6	52.3	-31.3	55.9	0.7	0.5
	Wenzhou	575	33.1	29.4	-11.1	50.5	-1.4	56.7	0.6	0.4	741	23.2	22.4	-3.4	45.8	-20.1	48.7	0.7	0.6
	Jiaxing	597	47.5	42.0	-11.7	38.3	-9.0	41.7	0.8	0.6	705	32.1	25.1	-21.6	35.4	-31.4	43.3	0.8	0.7
	Huzhou	621	47.6	44.0	-7.5	38.5	-8.4	40.7	0.7	0.5	731	21.6	16.0	-26.1	51.8	-45.0	65.6	0.8	0.7
Zhejiang	Shaoxing	621	50.9	41.0	-19.5	41.2	-22.5	45.6	0.7	0.5	678	26.6	17.6	-33.8	39.8	-40.4	51.6	0.8	0.8
	Jinhua	622	47.7	37.1	-22.1	39.5	-20.4	43.1	0.6	0.5	730	26.2	12.0	-54.3	58.9	-74.6	82.2	0.5	0.5
	Quzhou	617	41.2	40.1	-2.9	42.5	6.6	42.9	0.7	0.5	731	26.3	18.3	-30.3	48.8	-37.9	57.2	0.5	0.3
	Zhoushan	614	29.1	21.9	-24.7	42.5	-33.8	52.8	0.8	0.7	741	16.3	11.8	-27.7	40.9	-46.7	55.4	0.8	0.7
	Taizhou	618	38.7	28.9	-25.2	48.0	-17.6	53.7	0.6	0.5	723	22.2	17.9	-19.2	37.6	-26.2	44.7	0.8	0.7
	Lishui	617	32.5	30.3	-6.7	49.8	-3.5	53.4	0.6	0.3	710	18.4	13.1	-28.8	43.4	-22.0	48.8	0.7	0.6
	Hefei	624	75.0	69.5	-7.4	33.7	-5.5	35.0	0.7	0.5	726	34.3	28.5	-16.8	39.7	-21.6	47.5	0.7	0.5
	Wuhu	616	47.9	56.5	18.0	42.3	17.0	39.5	0.7	0.6	741	30.3	28.5	-6.1	32.2	-6.4	38.3	0.9	0.8
	Bengbu	622	72.0	61.5	-14.6	37.3	-14.6	40.9	0.7	0.5	725	27.3	24.6	-9.7	49.2	-12.2	55.5	0.6	0.4
	Huainan	620	85.3	62.4	-26.9	35.6	-32.2	42.1	0.7	0.6	739	28.8	18.2	-36.7	49.5	-49.1	67.7	0.7	0.6
Anhui	Maanshan	616	59.5	55.4	-6.9	35.6	-3.9	38.5	0.7	0.6	738	24.8	33.6	35.3	64.2	27.7	53.5	0.6	0.4
	Huaibei	615	84.9	59.6	-29.9	36.5	-36.1	43.0	0.7	0.5	734	30.4	27.7	-8.8	42.4	-13.0	43.3	0.5	0.3
	Tongling	621	74.6	73.6	-1.3	36.3	-6.6	36.9	0.7	0.5	741	29.3	24.9	-15.0	40.1	-22.2	50.0	0.8	0.6
	Anqing	616	75.7	65.9	-12.9	34.2	-10.7	38.4	0.7	0.5	740	19.8	27.5	39.2	68.4	40.5	64.2	0.6	0.5
	Huangshan	614	43.4	38.3	-11.6	52.8	-2.3	56.1	0.5	0.2	737	14.1	12.6	-10.9	51.4	-2.1	56.2	0.7	0.5

	Chuzhou	621	66.9	51.7	-22.7	37.5	-24.2	44.1	0.7	0.6	741	33.5	24.9	-25.6	37.0	-36.2	46.7	0.8	0.7
	Fuyang	597	96.2	67.9	-29.4	40.7	-34.7	48.6	0.7	0.5	738	28.3	21.1	-25.6	51.6	-21.5	58.9	0.6	0.3
	Suzhou	615	104.2	68.2	-34.5	38.5	-40.7	46.4	0.7	0.6	736	40.0	38.3	-4.3	38.4	-6.7	37.9	0.6	0.4
	Liuan	619	55.2	60.9	10.5	45.6	12.3	44.3	0.6	0.4	738	19.3	19.2	-0.5	48.3	9.0	52.6	0.7	0.5
	Bozhou	595	93.7	62.7	-33.0	41.0	-36.1	46.9	0.7	0.5	718	30.2	21.8	-27.7	49.9	-22.1	54.0	0.5	0.4
	Chizhou	612	81.5	74.6	-8.5	36.0	-13.6	39.0	0.6	0.4	723	24.3	25.3	4.4	48.0	3.0	54.7	0.8	0.6
	Xuancheng	612	63.7	54.5	-14.4	40.7	-17.2	44.4	0.7	0.4	741	22.3	19.6	-12.0	40.4	-12.2	45.8	0.8	0.7

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Province	City	Jan									Jul								
		Data pairs	Obs. ($\mu g/m^3$)	Sim. ($\mu g/m^3$)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R	Data pairs	Obs. ($\mu g/m^3$)	Sim. ($\mu g/m^3$)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R
Shanghai	Shanghai	530	52.3	49.9	-4.5	36.6	-4.3	34.7	0.7	0.5	714	53.2	50.4	-5.3	36.1	-11.5	37.0	0.7	0.5
	Nanjing	593	72.7	61.7	-15.1	40.1	-15.5	45.2	0.6	0.4	428	29.7	33.4	12.5	49.9	10.7	51.4	0.8	0.7
	Wuxi	615	79.3	63.0	-20.6	37.0	-24.2	41.7	0.7	0.5	736	48.5	40.2	-17.1	49.1	-30.5	54.2	0.6	0.4
	Xuzhou	566	147.7	80.9	-45.2	47.6	-60.1	63.1	0.6	0.5	696	64.8	39.3	-39.4	46.2	-49.1	58.3	0.6	0.5
	Changzhou	612	82.9	69.0	-16.7	36.1	-17.6	40.4	0.7	0.5	702	44.6	40.5	-9.2	39.0	-21.9	43.2	0.7	0.6
	Suzhou	430	64.2	58.3	-9.2	38.0	-4.3	39.0	0.7	0.5	611	53.4	48.6	-9.1	47.9	-18.1	49.0	0.6	0.4
	Nantong	421	61.2	50.7	-17.3	36.7	-14.1	37.6	0.7	0.5	652	66.1	49.1	-25.7	39.6	-31.2	47.9	0.6	0.4
Jiangsu	Lianyungang	581	85.4	58.0	-32.1	45.6	-34.9	53.5	0.6	0.5	632	51.5	28.3	-44.9	53.1	-57.4	69.8	0.5	0.2
	Huaian	603	101.5	71.9	-29.2	46.2	-34.9	53.5	0.6	0.4	693	58.7	43.2	-26.3	40.1	-33.4	48.8	0.6	0.4
	Yancheng	572	70.6	46.8	-33.7	47.6	-39.5	55.7	0.7	0.5	738	76.2	35.9	-52.8	56.1	-76.6	81.5	0.5	0.4
	Yangzhou	578	92.4	74.9	-18.9	37.7	-20.2	43.9	0.7	0.5	675	64.0	46.1	-28.0	41.8	-38.5	50.8	0.6	0.5
	Zhenjiang	598	95.9	59.4	-38.1	42.8	-50.5	55.9	0.6	0.5	675	65.6	39.7	-39.4	48.8	-52.8	63.5	0.6	0.5
	Taizhou	438	70.0	59.8	-14.7	41.7	-13.7	43.6	0.7	0.4	734	56.0	49.4	-11.8	40.0	-16.7	43.6	0.6	0.4
	Suqian	541	75.4	64.3	-14.7	39.8	-16.5	44.0	0.7	0.5	64	73.0	26.1	-64.2	64.5	-85.2	85.8	0.4	0.1
	Hangzhou	624	74.5	62.1	-16.6	37.9	-18.6	41.6	0.7	0.5	738	42.8	34.2	-20.1	32.1	-26.9	38.4	0.8	0.7
	Ningbo	622	55.4	51.9	-6.4	41.9	-12.7	43.6	0.7	0.5	736	43.6	40.4	-7.4	37.8	-14.2	38.6	0.8	0.6
	Wenzhou	573	66.0	44.4	-32.7	48.4	-35.2	58.7	0.5	0.4	721	51.6	51.6	-0.1	38.9	-11.7	40.5	0.7	0.5
	Jiaxing	593	64.1	60.4	-5.8	34.2	-6.3	35.7	0.7	0.5	704	51.6	43.6	-15.4	33.9	-24.5	40.2	0.8	0.7
	Huzhou	514	64.5	61.3	-5.0	38.2	-5.9	40.4	0.7	0.4	710	41.8	25.6	-38.7	59.5	-63.6	79.8	0.6	0.4
Zhejiang	Shaoxing	617	80.9	57.6	-28.7	41.8	-31.0	47.4	0.6	0.4	677	43.7	30.9	-29.4	37.3	-36.0	46.0	0.8	0.7
	Jinhua	507	62.8	50.7	-19.3	32.5	-19.5	36.4	0.7	0.5	684	43.2	21.4	-50.5	55.7	-67.3	74.4	0.5	0.3
	Quzhou	583	70.8	54.9	-22.4	39.2	-19.2	42.6	0.6	0.5	710	50.9	29.2	-42.6	50.9	-53.2	63.3	0.5	0.2
	Zhoushan	612	44.7	36.4	-18.5	36.6	-19.9	40.6	0.8	0.7	741	30.1	40.7	35.2	44.8	21.7	36.7	0.7	0.8
	Taizhou	613	52.3	43.0	-17.8	40.0	-12.4	43.7	0.7	0.6	723	40.4	44.7	10.9	33.7	5.5	32.6	0.8	0.7
	Lishui	515	43.8	46.5	6.0	47.9	8.0	48.9	0.6	0.3	651	38.9	28.1	-27.9	48.3	-23.7	52.2	0.5	0.2
	Hefei	389	94.2	93.4	-0.8	35.9	-0.8	34.2	0.6	0.4	622	51.2	48.8	-4.7	35.2	-7.0	37.4	0.8	0.6
Anhui	Wuhu	597	76.6	76.8	0.4	37.3	-1.1	37.4	0.7	0.5	727	52.0	46.5	-10.6	31.7	-9.7	36.2	0.8	0.7
	Bengbu	604	104.8	87.1	-16.8	41.1	-18.6	44.8	0.6	0.4	721	51.1	38.1	-25.4	49.5	-29.9	59.2	0.6	0.4

	Huainan	573	109.4	77.9	-28.8	38.9	-37.7	47.5	0.6	0.5	736	68.6	26.1	-61.9	63.3	-95.3	97.1	0.5	0.5
	Maanshan	536	81.3	76.0	-6.5	38.5	-6.9	40.7	0.6	0.4	699	48.9	53.8	10.1	40.4	7.5	40.3	0.7	0.6
	Huaibei	578	127.6	74.4	-41.7	44.1	-54.1	56.7	0.6	0.4	669	60.3	37.4	-38.0	47.3	-46.3	57.7	0.5	0.3
	Tongling	605	100.5	96.5	-4.0	36.6	-9.4	37.2	0.6	0.4	668	45.1	35.8	-20.7	40.2	-33.0	50.4	0.7	0.6
	Anqing	566	98.9	88.5	-10.5	34.8	-10.9	38.5	0.7	0.4	730	43.1	42.7	-0.9	43.0	-8.2	43.8	0.6	0.5
	Huangshan	509	55.8	52.8	-5.4	50.1	-3.3	49.7	0.4	0.0	735	43.3	23.5	-45.8	51.6	-65.4	70.9	0.5	0.4
	Chuzhou	599	105.9	74.3	-29.9	40.2	-35.4	48.5	0.6	0.4	683	54.0	43.0	-20.5	35.5	-27.2	42.9	0.8	0.6
	Fuyang	564	148.3	87.2	-41.2	46.9	-53.6	60.5	0.6	0.4	733	60.1	30.3	-49.5	55.7	-62.1	70.0	0.5	0.3
	Suzhou	497	145.6	84.5	-42.0	44.0	-52.6	55.2	0.6	0.4	637	53.7	52.9	-1.7	34.6	-5.4	33.0	0.6	0.4
	Liuan	507	77.5	81.2	4.8	45.8	5.9	45.3	0.5	0.3	729	47.0	31.2	-33.7	45.0	-36.6	51.1	0.5	0.4
	Bozhou	550	133.0	78.2	-41.2	47.0	-52.8	59.3	0.5	0.3	696	63.0	31.0	-50.9	56.6	-55.5	66.3	0.4	0.4
	Chizhou	561	118.6	108.7	-8.4	38.0	-12.3	39.7	0.6	0.3	731	55.4	50.0	-9.9	42.1	-19.0	48.6	0.7	0.5
	Xuancheng	507	88.0	75.1	-14.7	40.2	-18.0	43.5	0.6	0.3	728	41.9	36.4	-13.3	42.1	-14.9	46.0	0.7	0.6

256 (f) CO

Province	City	Jan									Jul								
		Data pairs	Obs. (μg/m^3)	Sim. (μg/m^3)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R	Data pairs	Obs. (μg/m^3)	Sim (μg/m^3)	NMB (%)	NME (%)	MFB (%)	MFE (%)	IOA	R
Shanghai	Shanghai	624	0.9	0.6	-35.6	38.6	-42.4	46.1	0.7	0.7	741	0.5	0.4	-22.0	36.1	-31.2	42.5	0.6	0.4
Jiangsu	Nanjing	606	1.0	0.7	-26.2	36.3	-26.4	41.3	0.6	0.4	709	1.0	0.4	-62.4	63.3	-90.4	92.4	0.4	0.2
	Wuxi	618	1.1	0.8	-30.0	37.2	-33.1	41.8	0.6	0.4	740	0.7	0.4	-44.3	48.3	-60.2	64.0	0.4	0.1
	Xuzhou	581	1.3	1.0	-21.7	35.1	-27.2	38.5	0.6	0.5	739	0.8	0.6	-24.5	48.3	-27.8	52.0	0.4	0.1
	Changzhou	621	0.9	0.9	-4.2	37.3	-1.0	38.1	0.6	0.3	701	0.7	0.5	-32.6	40.9	-36.6	46.2	0.5	0.3
	Suzhou	623	0.9	0.8	-17.0	28.2	-17.6	29.5	0.7	0.6	618	0.4	0.5	9.6	38.3	9.0	35.4	0.6	0.3
	Nantong	619	0.9	0.8	-9.9	27.8	-12.0	28.4	0.7	0.5	680	0.8	0.6	-27.5	38.1	-33.9	44.1	0.5	0.2
	Lianyungang	596	1.1	0.6	-39.4	43.4	-45.5	51.3	0.6	0.5	741	0.5	0.3	-30.4	38.1	-30.3	41.3	0.5	0.3
	Huaian	617	0.9	1.0	7.1	39.2	5.9	36.2	0.6	0.4	740	0.7	0.6	-7.5	36.2	-4.2	35.7	0.5	0.1
	Yancheng	617	0.7	0.6	-8.8	29.9	-6.4	29.0	0.7	0.6	739	0.9	0.4	-51.8	52.2	-72.0	72.4	0.4	0.3
	Yangzhou	624	1.0	0.8	-21.6	29.9	-24.3	32.9	0.7	0.6	689	0.6	0.5	-24.2	36.0	-27.0	40.1	0.5	0.2
	Zhenjiang	621	1.0	0.9	-6.8	28.6	-10.9	29.4	0.7	0.5	741	0.9	0.6	-29.0	37.1	-35.4	43.8	0.5	0.2
	Taizhou	500	1.0	0.7	-32.3	38.4	-38.3	44.7	0.6	0.4	736	0.7	0.5	-19.2	38.8	-21.3	40.3	0.4	0.1
	Suqian	619	1.2	0.7	-41.2	42.5	-54.7	55.8	0.6	0.6	66	0.4	0.3	-18.5	24.4	-19.3	25.6	0.5	0.2
Zhejiang	Hangzhou	624	1.0	0.7	-29.4	33.0	-34.5	38.5	0.6	0.5	740	0.7	0.4	-47.4	53.8	-61.7	69.8	0.4	-0.1
	Ningbo	623	0.8	0.6	-18.1	36.4	-24.1	39.5	0.6	0.4	740	0.6	0.3	-47.4	51.6	-65.9	69.6	0.5	0.3
	Wenzhou	575	0.7	0.6	-12.1	27.8	-10.5	29.2	0.7	0.5	741	0.6	0.4	-36.1	42.7	-48.3	54.4	0.6	0.4
	Jiaxing	597	0.8	0.7	-21.0	40.9	-13.2	42.2	0.6	0.4	705	0.7	0.4	-34.2	40.2	-46.8	51.9	0.5	0.4
	Huzhou	620	1.0	0.6	-36.9	37.7	-46.5	47.3	0.6	0.6	722	0.6	0.3	-55.4	55.6	-80.3	80.5	0.4	0.5
	Shaoxing	623	0.9	0.7	-19.0	31.2	-19.1	33.0	0.7	0.5	679	0.7	0.3	-54.7	56.1	-78.5	79.8	0.4	0.4
	Jinhua	623	0.9	0.6	-35.0	36.3	-42.7	44.3	0.6	0.5	734	0.6	0.2	-60.8	61.0	-86.2	86.5	0.4	0.4
	Quzhou	623	1.0	0.8	-11.8	36.5	-17.9	37.4	0.5	0.2	727	0.5	0.6	21.4	61.8	13.2	52.6	0.4	0.2

	Zhoushan	614	0.8	0.4	-51.2	51.5	-71.3	71.6	0.5	0.7	727	0.4	0.2	-56.9	57.1	-81.1	81.3	0.4	0.5
	Taizhou	622	0.8	0.5	-38.0	40.7	-42.9	46.1	0.5	0.5	741	0.6	0.2	-58.1	58.1	-84.3	84.3	0.4	0.7
	Lishui	621	0.5	0.4	-17.0	27.3	-20.1	30.8	0.7	0.5	712	0.5	0.2	-63.6	63.6	-93.3	93.3	0.4	0.7
Anhui	Hefei	618	1.0	0.8	-26.4	32.2	-27.8	35.3	0.7	0.6	732	0.7	0.4	-50.0	50.2	-66.8	67.1	0.4	0.5
	Wuhu	614	1.1	0.7	-33.2	40.0	-41.6	49.0	0.5	0.3	725	0.9	0.4	-56.9	57.8	-76.3	77.6	0.5	0.4
	Bengbu	621	1.0	0.7	-24.1	34.7	-30.9	38.8	0.7	0.5	739	0.6	0.3	-39.7	41.2	-48.4	50.1	0.5	0.4
	Huainan	615	1.3	0.8	-35.4	38.6	-44.1	47.3	0.6	0.4	740	0.8	0.3	-63.1	64.1	-94.3	95.7	0.4	0.4
	Maanshan	591	1.0	0.9	-7.7	36.5	-5.3	35.9	0.5	0.2	732	0.8	0.5	-46.1	50.6	-54.2	62.5	0.5	0.3
	Huaibei	596	1.4	1.7	22.0	52.6	6.8	41.7	0.4	0.3	737	0.8	1.4	81.7	89.2	50.0	57.3	0.3	0.2
	Tongling	604	0.9	0.8	-9.5	41.3	-0.3	45.3	0.6	0.4	736	0.7	0.4	-47.2	54.1	-50.9	65.3	0.5	0.4
	Anqing	620	0.8	0.9	7.3	30.2	7.0	28.5	0.6	0.4	739	0.5	0.5	1.5	39.5	-5.0	33.8	0.4	0.3
	Huangshan	619	0.7	0.5	-22.9	29.1	-27.3	33.4	0.7	0.6	739	0.7	0.2	-71.0	71.0	-108.8	108.8	0.3	-0.1
	Chuzhou	620	0.9	0.7	-25.6	31.3	-29.7	35.3	0.7	0.6	741	0.5	0.3	-30.1	38.5	-34.2	43.8	0.6	0.4
	Fuyang	587	1.1	0.8	-33.3	41.2	-37.0	48.4	0.6	0.5	736	0.5	0.3	-33.0	40.9	-25.4	40.5	0.5	0.6
	Suzhou	611	1.0	0.9	-9.6	44.9	-18.5	41.7	0.6	0.5	735	0.6	0.3	-42.6	43.4	-52.8	53.5	0.5	0.5
	Liuan	617	0.9	0.6	-27.1	35.6	-27.7	39.0	0.6	0.5	735	0.4	0.2	-30.9	36.0	-30.8	39.1	0.5	0.4
	Bozhou	598	1.3	0.8	-35.5	39.3	-44.1	48.1	0.6	0.5	723	0.9	0.3	-65.3	65.3	-95.2	95.2	0.4	0.5
	Chizhou	622	0.9	0.7	-24.6	33.5	-28.2	37.3	0.5	0.3	738	0.5	0.2	-54.7	55.2	-70.6	71.4	0.5	0.5
	Xuancheng	612	0.8	0.6	-19.1	27.8	-21.9	30.3	0.7	0.6	741	0.7	0.2	-65.5	65.5	-97.7	97.7	0.3	0.5

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