



Supplement of

Evolution of anthropogenic air pollutant emissions in Guangdong Province, China, from 2006 to 2015

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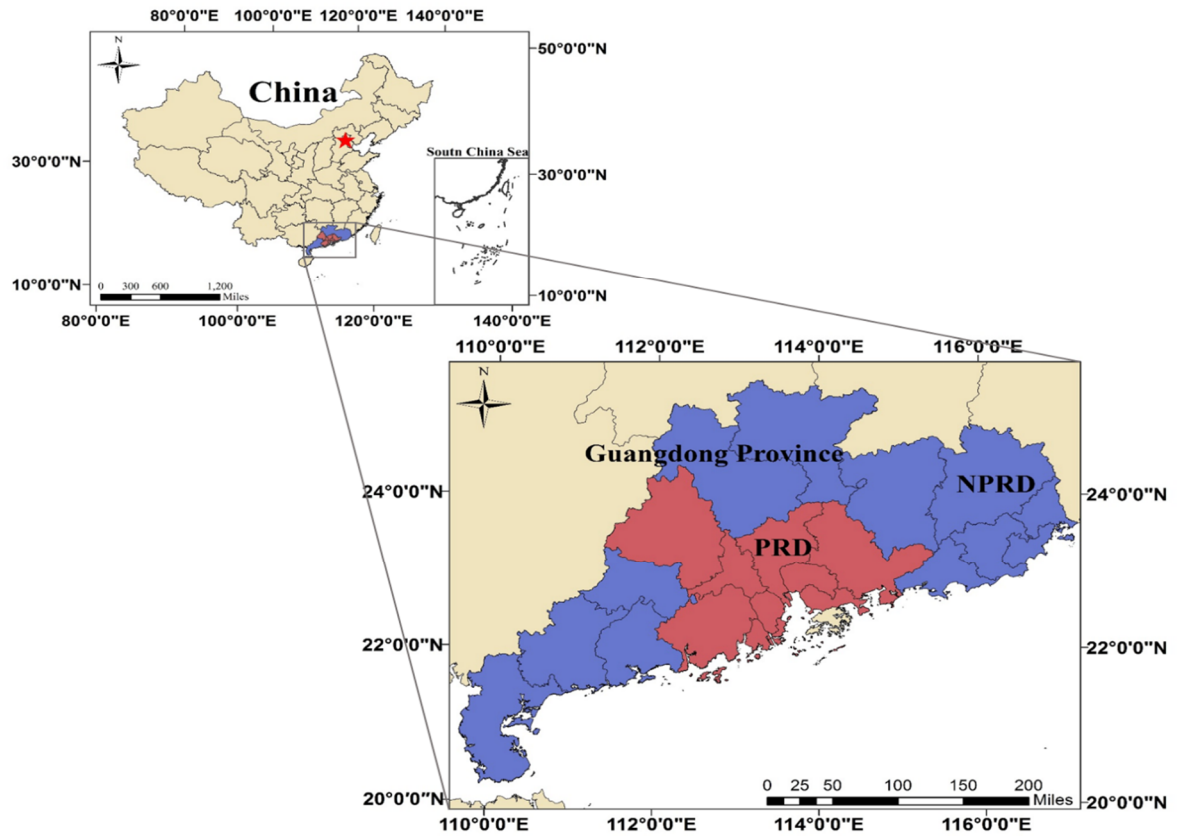


Figure S1. The geographical location of Guangdong Province, China

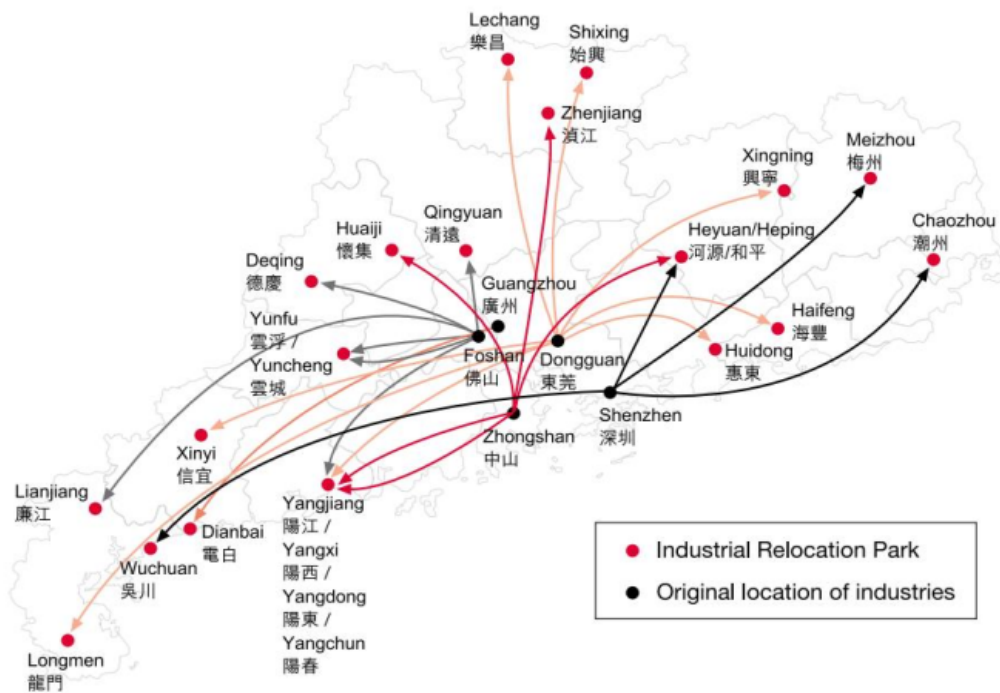


Figure S2. Government-designated industrial relocation parks in Guangdong province.
Source: Li and Fung Centre Research (2008)

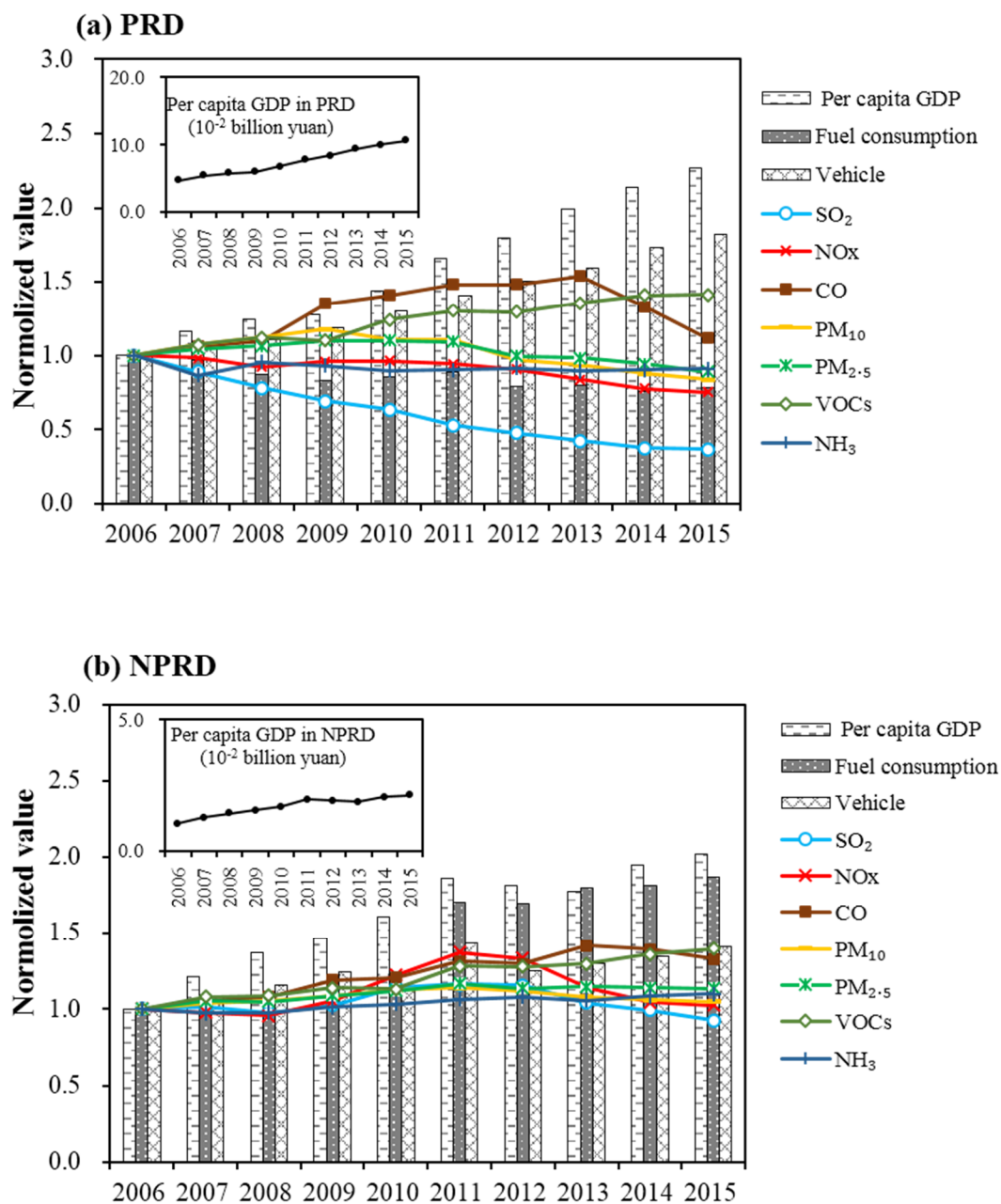


Figure S3. Trends in the air pollutant emissions, per capita GPD, fuel consumption and vehicle population in the **(a)** PRD **(b)** NPRD (all the data are normalized to the year 2006).

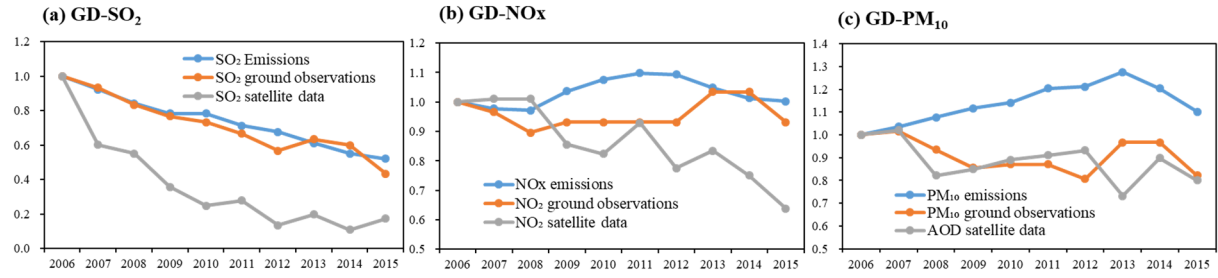
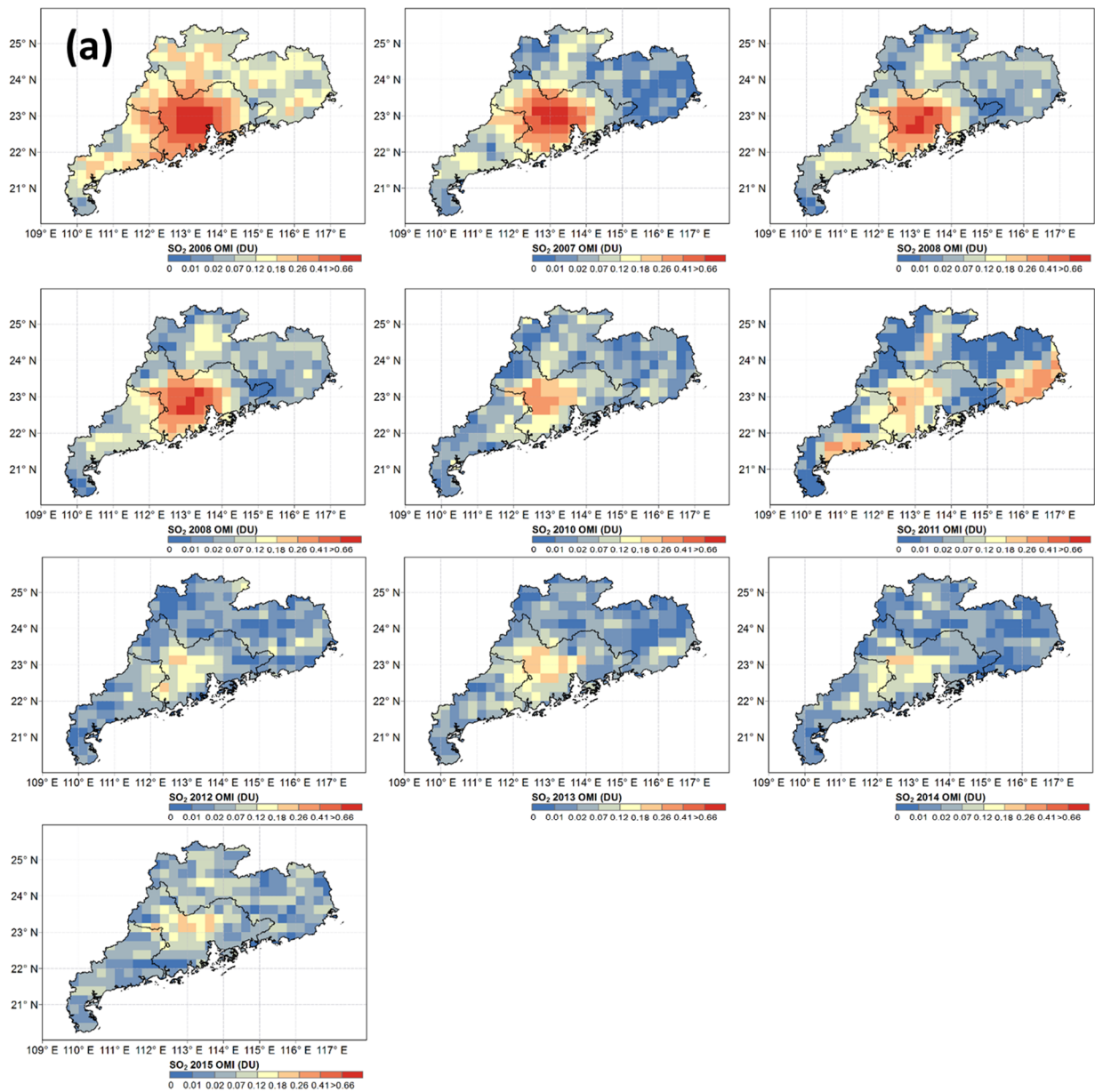
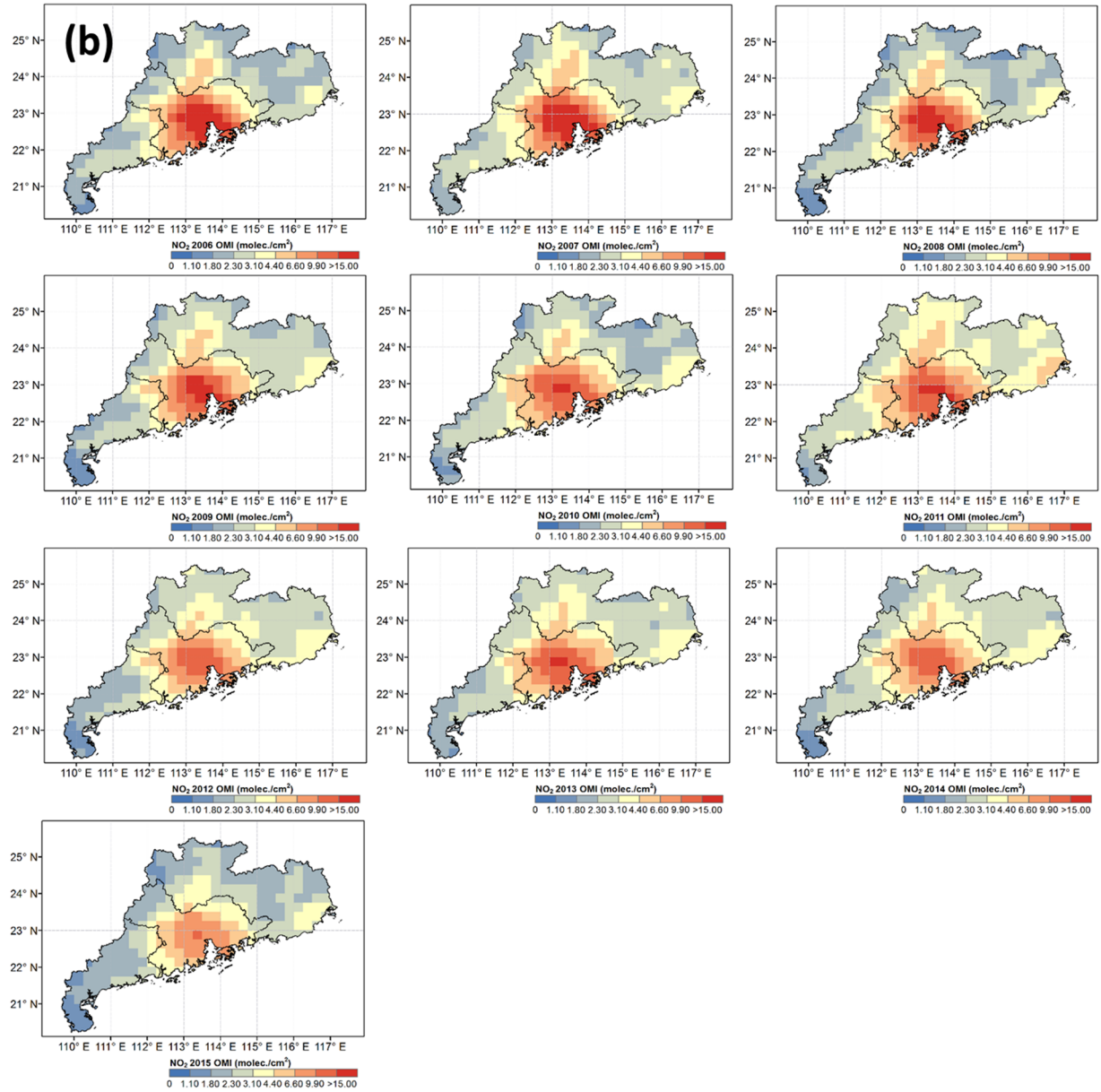


Figure S4. Comparison of emission trends of (a) SO_2 (b) NO_x (c) PM_{10} with ground-level/satellite measurements in the GD from 2006 to 2015. (All data are normalized to the year 2006).





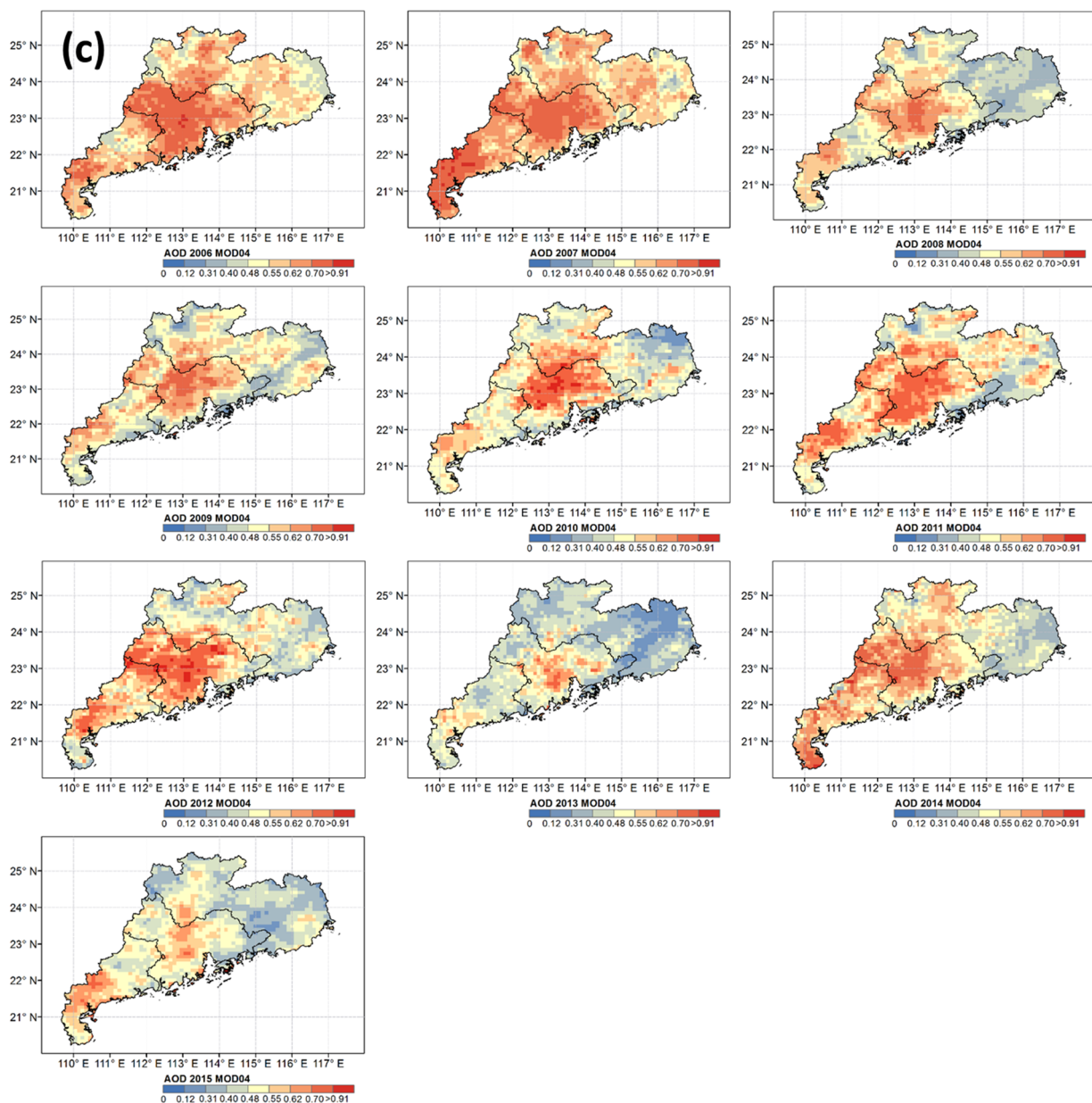
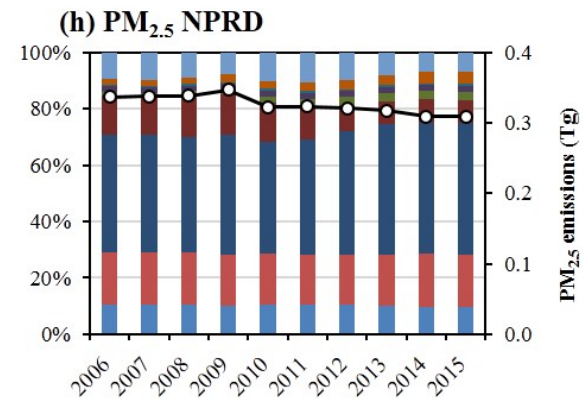
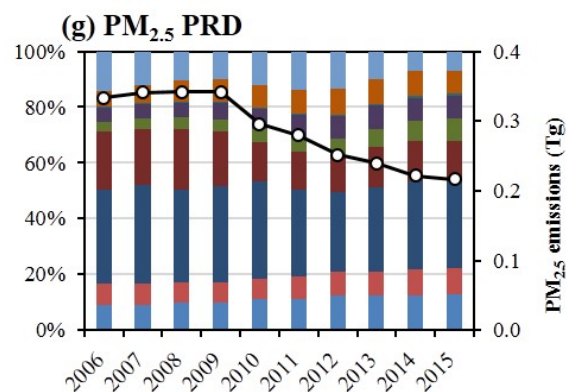
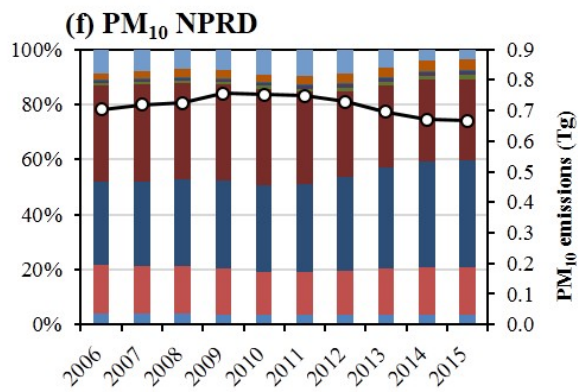
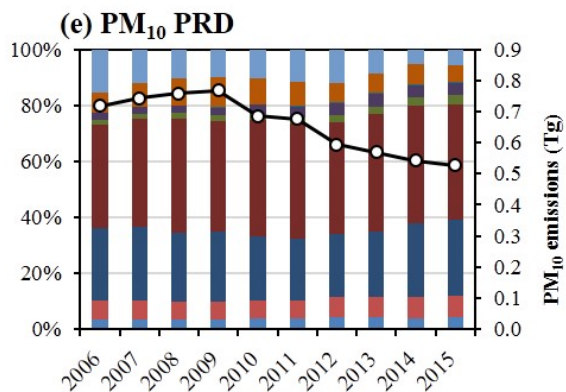
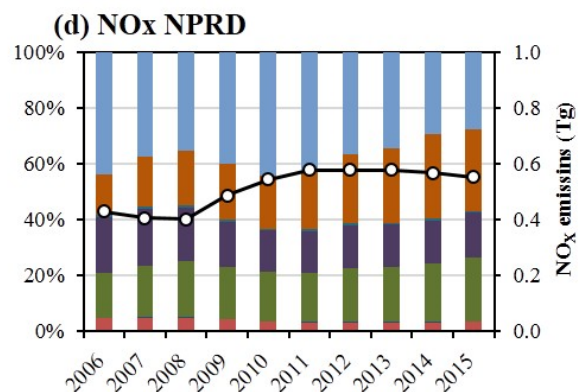
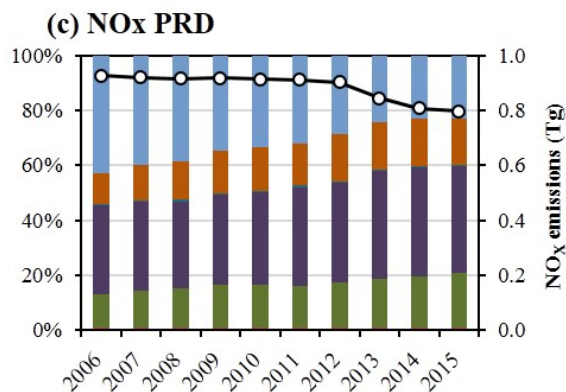
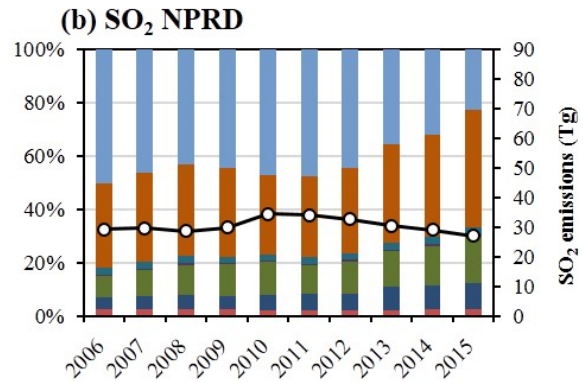
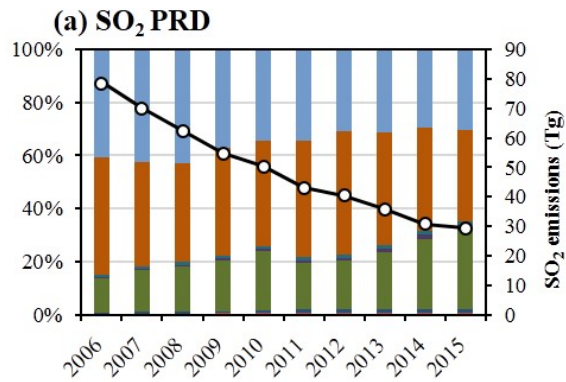


Figure S5. The spatial patterns of satellite observations in GD during 2006-2015. **(a)** SO₂, **(b)** NO₂, and **(c)** AOD.



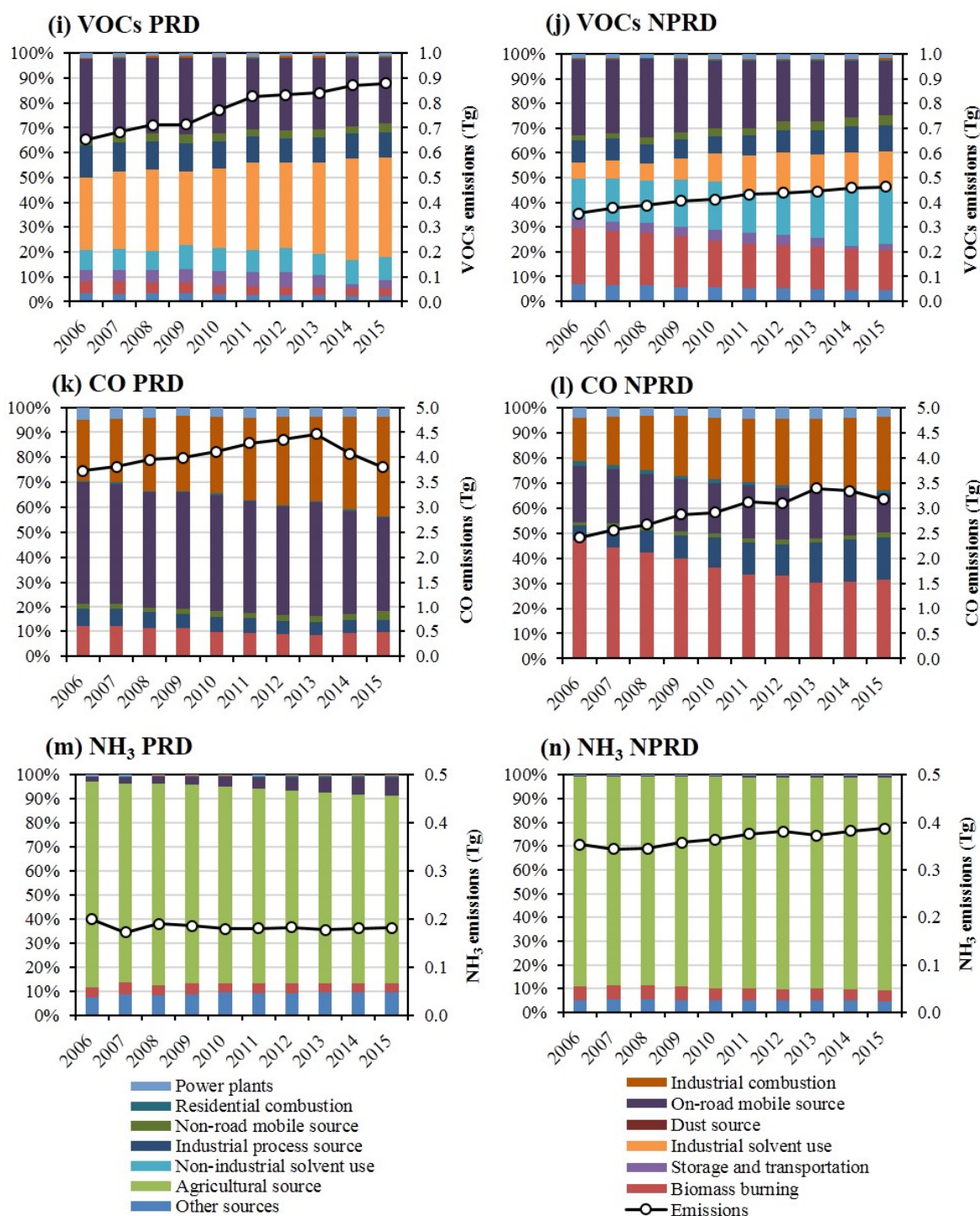


Figure S6. Source emission evolutions in the PRD and NPRD for **(a)-(b)** SO₂, **(c)-(d)** NO_x, **(e)-(f)** PM₁₀, **(g)-(h)** PM_{2.5}, **(i)-(j)** VOCs, **(k)-(l)** CO and **(m)-(n)** NH₃ from 2006 to 2015. The stacked column graphs show the emission contributions by source-category and year (left axle). The point plots show the total annual emissions (right axle).

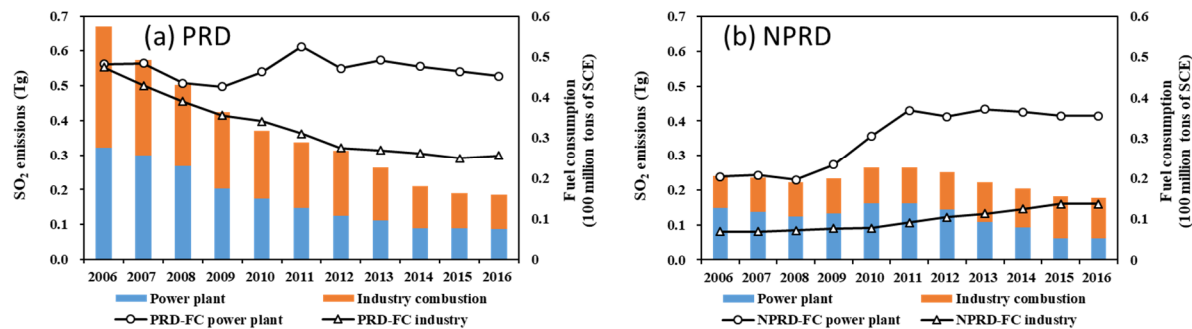


Figure S7. Trends of SO₂ emissions (left axle) and fuel consumption from industrial combustion (right axle) and power plants from 2006 to 2015. SCE represents standard coal equivalent; FC represents fuel consumption (i.e., coal, fuel oil, coke, and natural gas).

Table S1. The major regulations for emission control implemented during 2006-2015

Control category		Main Measures	Sources
Emission controls for power plants	Desulfurization	Manage strictly flue gas online monitoring in thermal power plants, making the operating efficiency of thermal power plants desulfurization facilities stably reach 85% or more.	1, 5
		New coal-fired units must be equipped with desulphurization facilities, and the comprehensive desulfurization rate reaches 95% or more.	6
		By the end of 2015, the comprehensive desulfurization rate of all the coal-fired thermal power units that are more than 125,000 KW has reached 95% or more.	9
	Control sulfur content of fuels	The sulfur content of coal in the thermal power plant is controlled below 0.7%; The sulfur content of industrial boiler and kiln is controlled below 0.6%, and the sulfur content of oil is controlled below 0.8%.	1, 9
	Nitrogen reduction and denitrification	Adopt low-nitrogen combustion technology in thermal power plants; Research and promote clean combustion technology and flue gas denitrification technology.	1, 3, 4, 5
		The coal-fired units more than 125,000 KW in GD will be all equipped with the nitrogen reduction and denitrification facilities, of which comprehensive denitrification efficiency is more than 70%.	6
		Complete low-nitrogen combustion and flue gas denitrification transformation; The circulating fluidized bed boiler generating units that cannot stably achieve the discharge standard must increase the flue gas denitrification facilities; The comprehensive denitrification efficiency is 85% or more.	9
	Dust removal	Implement special soot emission limit requirements of <i>Air Pollutant Emission Standards of Thermal Power Plants (GB13223-2011)</i> in coal-fired units.	1
	Shut down small thermal power	Shut down small heavy polluting thermal power plants; Develop large capacity, low energy consumption units; Transform low-efficiency units. Gradually phase out high energy consumption,	1

	units	heavy polluted processes and equipment.	
		By the end of 2007, shut down the province's small thermal power units which power is below 50,000 KW.	4
		Gradually shut down the conventional coal-fired thermal power units which power is below 100MW.	5
	Prohibit new coal-fired power plants or oil-fired power plants	Forbid to plan and station new coal-fired or oil-fired power plants.	1
	Improve the heating system	Adopt cogeneration enterprises as a heating source in new industrial parks; Plan and build a sound central heating system.	8, 9
	Fuel power plants-oil to gas	Encourage oil-fired power plants to implement "oil to gas" project.	11
	Ultra-low emission improvement of coal-fired power plants	Promote ultra-low emissions on >300,000 KW coal-fired generating units, >100,000 KW self-owned coal-fired generating units and other qualified coal-fired generating units, by the end of 2020, the air pollutant concentrations of coal-fired units reach the emission limit of the gas turbine in GD.	1, 5, 8
Industrial emission controls	Boiler renovation	By the end of 2012, strive to eliminate coal-fired, heavy oil-fired and wood-fired industrial boilers, which are < 4t/h or >10t/h over an 8-year lifetime.	11
		By the end of June 2016, basically eliminate <10t/h boilers in the PRD, which use high-polluting fuel but located outside the highly polluting fuel forbidden area.	8
		Forbid to build, expand and rebuild <20t/h industrial boilers that use highly polluting fuels in key control areas; Prohibit the construction of <10t/h industrial boilers that use highly polluting fuels	4

		in other urban districts and the industrial parks.	
	Control sulfur content of fuel	Control the sulfur content of coal <0.7% and that of oil <0.8% in enterprises without desulphurization facilities and those fail to meet the requirements must use sulfur fixation or desulfurization agent.	8
		Prohibit the use of fuel with sulfur content >1.5%. The sulfur content of coal must be controlled <0.6%, ash content be controlled <15%. The sulfur content of oil must be controlled below 0.8%.	6
	Flue gas desulfurization	Strengthen the treatment of sulfur dioxide of industrial furnace flue gas, and the existing oil refining equipment, nonferrous metal smelting equipment, building materials kilns and coke oven, etc. should be installed flue gas desulfurization facilities.	6, 9
		Promote the iron and steel industry sintering machine flue gas desulfurization, and the new sintering machine should be equipped with flue gas desulfurization and denitrification facilities.	7
	Nitrogen reduction and denitrification	Encourage low nitrogen combustion technology and flue gas denitrification in the cement industry, especially in the new dry cement kiln with >2000 tons of clinker a day.	8
		By the end of 2015, Coal-fired industrial boilers with >20t/h capacity must complete low-nitrogen combustion technology transformation. Additionally, Coal-fired industrial boilers with >65t/h capacity encourage construction of flue gas denitrification project.	8
	Desulfurization and dust removal	All industrial boilers with >10t/h capacity should be converted to use clean energy or equipped with efficient desulfurization and dust removal facilities to ensure pollutants satisfy stably emission standards.	1
	Prohibit new/extended cement plants	No longer plan to build and expand new cement plants in principle; Eliminate high energy consumption and heavy polluted production processes; Phase out shaft kiln gradually.	11
	Ceramic industries-coal to	Promote the ceramic manufacturing enterprises to use the natural gas and other clean energy; denitrification measures should be taken if nitrogen oxides cannot satisfy stably the emission	5

	gas	standards.	
	Centralized heating	Realize basically central heating in industrial parks with heating demand in the PRD.	9
	Pollution control of non-metallic minerals industries	Speed up the elimination of high energy consumption and seriously polluted old-fashioned production processes. By the end of 2012, eliminate completely backward cement production capacity, and "horizontal sheet process" backward flat glass production capacity.	6
		All building materials kilns and sintering equipment without electrostatic precipitators (ESP) should be installed efficient dust removal facilities.	7
		By the end of 2010, all cement enterprises in the PRD need to install efficient dust removal equipment, dust removal efficiency should not be less than 95%.	11
		Promote the implementation of dust suppression measures in the raw materials transportation, storage, product packaging, drying, grinding, calcination and other processes for the cement enterprises; Control effectively fugitive dust emissions.	9, 11
Volatile Organic Compounds (VOCs) controls	Implementation of environmental protection coatings/strict end-of-pipe controls	Automobile manufacturing, shipbuilding, container manufacturing, and other surface coating industry use low VOCs content paint that meets the environmental requirements; VOCs removal efficiency of the processes with solvent-based paint is up to 90%.	9, 11
		Printing, shoemaking, furniture manufacturing, electronics manufacturing, and other industries to promote the use of low VOCs raw materials, organic waste gas purification rate is up to 80%.	6, 9, 10, 11
		Reduce sharply VOCs containing architectural coatings, household solvents, and other products, the reduction rate is up to 80%.	10
		The proportion of low VOCs content paint use in new industrial coating project is more than 50%; The proportion of the use of low VOCs content of the total paint coating in new vehicle manufacturing and maintenance coating project is not less than 80%.	10, 11
	Implementation of LDAR	Promote Comprehensively leak detection and repair (LDAR) technology, by the end of 2015 all oil refining enterprises using LDAR technology in the PRD; By the end of 2017, apply fully LDAR	11

	technology of key industries	technology by all the oil refining enterprises, organic chemicals, and pharmaceutical chemicals and other key enterprises in GD.	
		Liquid organic materials should be sealed storage in key cities, low boiling point organic material storage tank should be set to maintain and equipped with the nitrogen seal device, the larger tank should use effectively seal inner (outer) floating roof tank, large storage tank should use efficient floating roof tank and nitrogen seal device.	6, 9
	Oil and gas recovery	By the end of 2011, conduct comprehensively oil and gas recovery and management, and complete all the gas stations, tankers and oil depots of oil and gas comprehensive management and acceptance in the PRD; By the end of 2012, complete integrated oil and gas management in the other region.	9
		By the end of 2014, complete the oil and gas storage tank management in gas stations, oil depots, tankers, and chemical enterprises and construct online monitoring system in oil and gas recovery.	11
		Strengthen the daily inspection of oil and gas recovery facilities in gas stations; Increase recovery efficiency of oil and gas reach up to more than 80%.	4
Motor vehicle emission controls	Improve emission standards	Since January 1, 2007, the national III emission standards have been carried out in advance in the PRD. Since July 1, 2007, the national III emission standards have been adopted in GD.	6, 7
		Implement the emission standards for vehicles national IV and motorcycles national III, and prohibit the registration and transfer procedures for automobiles and motorcycles that do not meet the corresponding standards.	11
		Since December 31, 2015, vehicle national V emission standards has been implemented in advance in the PRD, the scope includes light ignition engine vehicles and public transportation, sanitation, postal heavy compression ignition engine vehicles.	4
	Improve oil quality	Improve the quality of oil products, and promote vigorously the national III vehicle fuel standards in GD.	5, 7
		Comprehensively promote the use of GD III fuel standards in refined products, and strive for the	6, 7

		gradual supply of refined oil products for GD IV fuel standards in the PRD in 2010.	
		Improve the quality of vehicle fuel, and supply fully GD IV vehicle fuel in the PRD; Supply gradually GD IV vehicle fuel in the other region.	9
		By the end of 2014, supply fully of GD V automotive gasoline in the PRD.	6, 7, 9, 11
	Yellow label car management	Speed up the elimination of high emission vehicles, eliminate all yellow cars in the Pearl River Delta region by the end of 2015.	11
		In 2015, the proportion of the restricted area of yellow-label cars in the PRD was not less than 40% of the urban districts.	4, 6, 7, 11
	Implement the I/M system	Implement comprehensively vehicle emission inspection and maintenance (I/M) system.	9, 11
	Carry out green traffic	Implement the bus priority development strategy, optimize the layout of the public transport network, strengthen walking, bicycle transportation system construction, improve public transport, walking, biking proportion, and reasonably control the amount of motor vehicles.	11
		In 2015, new energy vehicles are up to 20% among the added or updated buses in the PRD; In new or updated vehicles of passenger transport, taxi, sanitation, city logistics, and other public services, the proportion of the total new energy vehicles are up to 20%.	5
Non-road mobile source controls	Control sulfur content of fuels	Promote the use of low sulfur diesel, and speed up the elimination of highly polluting ship and machinery.	7
		Establish ship emission control area in the PRD, and gradually implement the use of fuel that sulfur content is less than 0.5% _{m/m} during the ship moored.	11
	Connect Ship to shore electricity	By 2017, 30% of container, passenger ship, and cruise specialized wharves have the capability to supply ships with shore power.	11
		New coastal cruise berths and container berths of more than 100 thousand tons need to be equipped with shore power facilities; By the end of 2017, working vessels and harbor management vessels have basically realized the use of shore power.	11

		By 2020, 90% of ships, official ships using shore power to berth and land in the main ports of the PRD water area, and 50% of container, passenger ship, and cruise specialized wharves have the capability to supply ships with shore power.	11
	Port machinery-oil to electricity	By the end of 2017, basically complete the "oil to electricity" transformation in coastal and inland port rubber-tired container gantry crane; Encourage to develop "oil to electricity" transformation in other port handling machinery and equipment.	11
Emission controls for dust sources	Building dust control and management	Strictly implement the construction site enclosed and removal of refuse and clay residue, spray dust and other measures, and strive to achieve the "six 100%" (namely 100% block of construction site, 100% sand cover, 100% road hardening, 100% sprinkling of demolition, 100% rinse wheel and body when transport vehicles go outside with sealed and no leakage, 100% green of temporary not developed sites).	9
		Promote the control technology in construction dust; Establish dust source dynamic information database and particulate matter online monitoring system.	9, 11
		Construction site muck and powdery materials are fully enclosed transport and equipped with a global positioning system (GPS) in transport vehicles.	9, 11
		The total construction area of 100 thousand square meters or more shall be regulated by the installation of dust video surveillance equipment.	9, 11
	Road dust control	Control pollution of road dust, and increase the frequency of road cleaning; The rate of roads cleaning in urban districts reaches more than 85%.	7
Management for living area source	Dining fumes	Strengthen the division of catering service and their pollution prevention and control work	9
		Promote the use of efficient purification type household smoke exhauster; Forbid open-air barbecue or open-air cooking with lampblack in the main urban districts.	9, 10, 11
		Strengthen the control of lampblack emission in the catering industry and achieve the standard discharge, and the normal utilization rate of facilities shall be no less than 95%.	7, 9
Adjustment of	Total control of	By the end of 2015, the total consumption of coal was less than 1.6 tons in the PRD.	7

energy structure	coal consumption	By 2017, the proportion of coal to total energy consumption in GD has dropped to less than 36%, and the total coal consumption has achieved downward in the PRD.	9
	Expand the supply range of natural gas	Natural gas pipelines are accessible to industrial parks in the PRD which are in need of gas.	9

*The number “1-11” represent the main documents as follows:

NO.	Release Year	Main documents
1	2004	Outline plan for environmental protection in the Pearl River Delta (2004-2020)
2	2006	Rectification content and requirements of the provincial control of key pollution sources online monitoring system
3	2006	Outline plan of environmental protection of Guangdong province (2006-2020)
4	2006	Planning for environmental protection and ecological construction in Guangdong Province in 11 th Five-Year
5	2010	Integrated planning for environmental protection in the Pearl River Delta (2009-2020)
6	2010	Clean air action plan for the Pearl River Delta in Guangdong province
7	2011	Planning for Guangdong province environmental protection and ecological construction in 12 th Five-Year
8	2012	Guangdong industrial boiler pollution remediation program (2012-2015)
9	2014	Action plan for air pollution prevention and control in Guangdong province (2014-2017)
10	2014	About volatile organic compounds in key industries (2014-2017)
11	2015	Guangdong provincial environmental protection planning in 13 th Five-Year (2015-2020)

Table S2. Source classification in Guangdong Province

Category	Sub-category	Category	Sub-category
Power plants			Electronics coating
Industrial combustion			Appliance coating
Residential combustion			Furniture surface coating
On-road mobile source	Heavy-duty gasoline vehicle (HDGV)	Industrial process source	Shoemaking
	Heavy-duty diesel vehicle (HDDV)		Printing
	Light-duty gasoline vehicle (LDGV)		Textile fabric printing
	Light-duty diesel vehicle (LDDV)		Artificial board
	Heavy-duty gasoline truck (HDGT)		Office supply
	Heavy-duty diesel truck (HDDT)		Vegetable oil process
	Light-duty gasoline truck (LDGT)		Alcohol production
	Light-duty diesel truck (LDDT)		Food production
	Bus		Pharmacy
	Taxi		Pulp and paper manufacturing
Non-road mobile source	Motorcycle		Synthetic rubber
	Airplane		Coating manufacturing
	Marine		Chemical fiber
	Fisher		Oil refinery
	Agricultural machinery		Cement
	Farm transport vehicle		Bricks

	Construction machinery		Ceram
	Locomotive		Glass
	Harbor machinery		Sulfuric acid
Dust source	Road dust		Sintering
	Construction dust		Iron
Storage and transportation	Oil refinery storage		Steel
	Oil products transportation		Plastics manufacturing
	Gas station		Synthetic resin
Biomass burning	Household straw		Tire manufacturing
	Household firewood		Synthesis ammonia
	Straw open burning	Non-industrial solvent use	Personal domestic product
	Forest fire		Architecture surface coating
Agricultural source	Livestock		Pesticide
	Agriculture fertilizing		Asphalt paving
Industrial solvent use	Vehicle coating		Decontaminating and degreasing
	Shipping coating		Dry-cleaning
	Container coating	Other sources	Human body
			Cooking

Table S3. Data type, data source and estimating methods of emission sources

Category	Sub-category	Data type	Data source	Method
Power plants		Fuel consumption by fuel types	CSPG(2007-2014); GDPSR(2006,2010,2012,2014,2015)	Zheng et al., 2009
	Industrial combustion	Fuel consumption by fuel types	GDPSR(2006,2010,2012,2014,2015); GDPBS(2007-2016)	Zheng et al., 2009
	Residential combustion	Fuel consumption by fuel types	CEBS(2007-2016); GDPBS(2007-2017)	Manual ^a
On-road mobile source		The number of light/heavy passenger car/truck, bus, taxi, and motorcycle, VKT	GDPBS(2007-2016); GDPCSY(2007-2017); A field survey	Pan et al., 2015
	Airplane	The number of landing take-off (LTO)	CAAC (2006-2015)	Zhang et al., 2010
	Marine	freight volume, transport distance of the main shipping lines	GDPBS(2007-2017); A field survey	Li et al., 2017
	Fisher	The power of fisher	GDPABS(2007-2016)	Zhang et al., 2010
	Agricultural machinery	The number of agricultural machinery	GDPABS(2007-2016)	Zhang et al., 2010
Non-road mobile source	Farm transport vehicle	The number of farm transport vehicle	GDPABS(2007-2016)	Manual ^a
	Construction machinery	Construction areas and the fuel consumption of construction of machinery	GDPBS(2007-2016); CESY(2007-2016)	Zhang et al., 2010
	Locomotive	The fuel consumption of locomotive, passenger and goods volume by railroad	CTBS(2007-2016); GDPCSY(2007-2016)	Manual ^a
	Harbor machinery	The throughput of container and bulk cargo	CPBS(2007-2016)	Fan et al., 2017
	Dust source	Road dust	The length road by road types, GDPCSY(2007-2016);	Peng et al., 2013

		traffic flow	A field survey	
	Construction dust	Construction areas, Construction cycles	GDPCSY(2007-2016)	Yang, 2014
Industrial process source	All	Product output by types	GDPCSY(2007-2016)	Pan et al., 2015
	Vehicle coating	Product output by types	GDPCSY(2007-2016)	Zheng et al., 2009
	Shipping coating	The usage of print for shipping	BSPRD(2006,2010,2012,2 014,2015)	Zheng et al., 2009
	Container coating	Product output by types	GDPCSY(2007-2016)	Zheng et al., 2009
	Electronics coating	Product output by types	GDPCSY(2007-2016)	Zheng et al., 2009
	Appliance coating	Product output by types	GDPCSY(2007-2016)	Zheng et al., 2009
	Furniture surface coating	Product output by types	GDPCSY(2007-2016)	Manual ^a
Industrial solvent use	Shoemaking	Product output by types	GDPCSY(2007-2016)	Manual ^a
	Printing	Output value	GDPCSY(2007-2016)	Zheng et al., 2009
	Textile fabric printing	Product output by types	GDPCSY(2007-2016)	Manual ^a
	Artificial board	Product output by types	GDPABS(2007-2016); GDPCSY(2007-2016)	Manual ^a
	Office supply	The number of industrial enterprises of manufacture of cultural, educational, sports and entertainment articles	GDPBS(2007-2016)	Manual ^a
	Personal domestic product	Population	GDPBS(2007-2016)	Zheng et al., 2009
Non-industrial solvent use	Architecture surface coating	Floor space of buildings completed	GDPBS(2007-2016); CEBS(2007-2016)	Manual ^a
	Pesticide	The usage of pesticide	GDPABS(2007-2016)	Manual ^a
	Asphalt paving	The areas of new road	GDPBS(2007-2016)	Manual ^a
	Decontaminating and degreasing	Population	GDPBS(2007-2016)	Manual ^a

Storage and transportation	Dry-cleaning	Population	GDPBS(2007-2016)	Manual ^a
	Oil refinery storage	Production of gasoline and diesel	CEBS(2007-2016)	Manual ^a
	Oil products transportation	Throughput of gasoline and diesel	CEBS(2007-2016)	Manual ^b
	Gas station	Sale volume of gasoline and diesel	CEBS(2007-2016)	Manual ^b
Agricultural source	Livestock	Product output by livestock types	GDPABS(2007-2016)	Manual ^b
	Agriculture fertilizing	The usage of agriculture fertilizer	GDPABS(2007-2016)	Manual ^b
	Household straw	Straw consumption	CEBS(2007-2016); GDPBS(2007-2016)	He et al., 2011
Biomass burning	Household firewood	Fuelwood consumption	CEBS(2007-2016); GDPBS(2007-2016)	He et al., 2011
	Straw open burning	The output of rice and other crop yields	GDPBS(2007-2016)	He et al., 2011
	Forest fire	The areas of fires	GDPABS(2007-2016)	He et al., 2011
Other sources	Human body	Population	GDPBS(2007-2016)	Shen et al., 2014
	Cooking	Population	GDPBS(2007-2016)	Manual ^a

CSPG is China Southern Power Grid;

GDPSR is Guangdong provincial pollutant statistical reports;

GDPBS is Guangdong Statistical Yearbook;

CEBS is China Energy Statistical Yearbook;

GDPCSY is Guangdong provincial 21 city Statistical Yearbooks;

CAAC is Civil Aviation Administration of China;

GDPABS is Agricultural Statistical Yearbook of Guangdong;

CTBS is China Transport Statistical Yearbook;

CPBS is China Port Statistical Yearbook;

Manual ^a is the Guideline of Air Pollutant Emission Inventory Development for Chinese Cities;

Manual ^b is Emission Inventory Handbook for Guangdong Province and Hong Kong.

Table S4. NO_x emission factors for power plants, industrial combustion and on-road mobile source

Category	Subcategory	Type	EFs	Unit	References
Power plants	Coal	<300MW, without LNB	6.68	g/kg	Zhao et al., 2010
		<300MW, with LNB	4.3	g/kg	
		≥300MW, with LNB	5.58	g/kg	
	Fuel oil		10.06	g/kg	Tian, 2003
	Natural gas		1.76	g/m ³	Zhao and Ma, 2008
industrial combustion	Coal		4.29	g/kg	Zhang et al., 2007
	Fuel oil		5.84	g/kg	Tian, 2003
	Natural gas		1.76	g/m ³	Zhao and Ma, 2008
	Coke		4.8	g/kg	Zhao and Ma, 2008
	HDGV		7.759	g/VKT	2007-based IVE
On-road mobile source	HDDV		13.515	g/VKT	2007-based IVE
	LDGV		0.814	g/VKT	2007-based IVE
	LDDV		0.976	g/VKT	2007-based IVE
	HDGT		6.906	g/VKT	2007-based IVE
	HDDT		13.524	g/VKT	2007-based IVE
	LDGT		1.689	g/VKT	2007-based IVE
	LDDT		1.135	g/VKT	2007-based IVE
	Bus		14.191	g/VKT	2007-based IVE
	Taxi		0.855	g/VKT	2007-based IVE
	Motorcycle		0.05	g/VKT	2007-based IVE

Table S5. PM₁₀ emission factors for power plants, industrial combustion and dust source

Category	Subcategory	Type	EFs	Unit	References
Power plants	Coal	Pulverized coal furnace, without control	1.5	g/kg	Zhao et al., 2010
		Pulverized coal furnace, with ESP ^a	0.065	g/kg	
		Pulverized coal furnace, with wet scrubber	0.291	g/kg	
		Pulverized coal furnace, with FF ^b	0.0034	g/kg	
		Grate-fired furnace, without control	0.26	g/kg	
		Grate-fired furnace, with ESP ^a	0.02012	g/kg	
		Grate-fired furnace, with wet scrubber	0.054	g/kg	
	Fuel oil		0.85	g/kg	Zhang, 2005
	Natural gas		0.24	g/m ³	Zhao and Ma, 2008
	Coal	Pulverized coal furnace/grate-fired furnace	28.08/5.4	g/kg	Zhang, 2005
industrial combustion	Fuel oil		1.03	g/kg	Zhang, 2005
	Natural gas		0.24	g/m ³	Zhao and Ma, 2008
	Coke		0.288	g/kg	Zhao and Ma, 2008
	Road dust		1.60	g/VKT	Peng et al., 2013
Dust source	Construction dust	Earthwork excavation	0.41	g/m ² ·h	Yang, 2014
		Foundations	0.14	g/m ² ·h	
		Earthwork backfill	0.2012	g/m ² ·h	
		General construction	0.11	g/m ² ·h	

^a is electrostatic precipitators; ^b is Fabric filter

Table S6. PM_{2.5} emission factors for power plants and industrial process source

Category	Subcategory	Type	EFs	Unit	References
Power plants	Coal	Pulverized coal furnace, without control	0.4	g/kg	Zhao et al., 2010
		Pulverized coal furnace, with ESP ^a	0.032	g/kg	
		Pulverized coal furnace, with wet scrubber	0.135	g/kg	
		Pulverized coal furnace, with FF ^b	0.0019	g/kg	
		Grate-fired furnace, without control	0.1	g/kg	
		Grate-fired furnace, with ESP ^a	0.008	g/kg	
		Grate-fired furnace, with wet scrubber	0.032	g/kg	
industrial combustion	Fuel oil		0.62	g/kg	Zhang, 2005
	Natural gas		0.17	g/m ³	Zhao and Ma, 2008
	Coal	Pulverized coal furnace/grate-fired furnace	5.4 /1.89	g/kg	Zhang, 2005
	Fuel oil		0.67	g/kg	Zhang, 2005
	Natural gas		0.17	g/m ³	Zhao and Ma, 2008
	Coke		0.144	g/kg	Zhao and Ma, 2008

^a is electrostatic precipitators; ^b is Fabric filter

Table S7. VOCs emission factors for solvent use and on-road mobile source

Category	Subcategory	Type	EFs	Unit	References
Industrial solvent use	Appliance coating	Appliance	0.2	kg/piece	Manual ^a
	Furniture surface coating	Metal furniture	0.4	kg/piece	Manual ^a
	Printing	Output value of printing	20.68	kg/(10000 yuan· year)	Report
Non-industrial solvent use	Architecture surface coating	Water-based paints	120	g/kg	Manual ^a
		Solvent-based paints	450	g/kg	Manual ^a
On-road mobile source	HDGV		7.924	g/VKT	2007-based IVE
	HDDV		1.535	g/VKT	2007-based IVE
	LDGV		1.422	g/VKT	2007-based IVE
	LDDV		0.395	g/VKT	2007-based IVE
	HDGT		8.197	g/VKT	2007-based IVE
	HDDT		1.596	g/VKT	2007-based IVE
	LDGT		1.978	g/VKT	2007-based IVE
	LDDT		0.749	g/VKT	2007-based IVE
	Bus		1.62012	g/VKT	2007-based IVE
	Taxi		1.493	g/VKT	2007-based IVE
	Motorcycle		3.69	g/VKT	2007-based IVE

Noted: In the sub-category of solvent use, EFs we listed here were the major contributors of solvent use

Manual ^a is the Manual of Air Pollutant Inventory Emission for Chinese Cities;

Report is *Study on air pollutant emission factors and the second phase of the emission investigation in Foshan*, edited by Guangdong Polytechnic of Environmental Protection Engineering South China University of Technology, and published in Environmental Protection Agency (EPA) of Foshan.

Table S8. NH₃ emission factors for agricultural source

Category	Subcategory	Type	EFs	Unit	References
Agricultural source	Livestock	Pork	3.061	kg/head	Shen et al.,
		Dorking	0.052	kg/head	2014
	Agriculture fertilizing	AC ^a /urea/AN ^b /AS ^c /others	24.29/24.29/7.83/2.61	%	Shen, 2014

^a is Ammonium carbonate; ^b is Ammonium nitrate; ^c is Ammonium sulfate

Table S9. CO emission factors for biomass burning and on-road mobile source

Category	Subcategory	Type	EFs	Unit	References
Biomass burning	Household straw	Straw consumption	82.18	g/kg	He et al., 2011
	Household firewood	Fuelwood consumption	63.63	g/kg	
	Straw open burning	The output of rice/other crop yields	78.45	g/kg	Zhang et al., 2013
		Wheat straw/maize stover	60/53	g/kg	Li et al., 2007
	Forest fire	The areas of fires	113	g/kg	Chang and Song, 2010
	HDGV		82.903	g/VKT	2007-based IVE
	HDDV		6.765	g/VKT	2007-based IVE
On-road mobile source	LDGV		9.010	g/VKT	2007-based IVE
	LDDV		1.132	g/VKT	2007-based IVE
	HDGT		38.433	g/VKT	2007-based IVE
	HDDT		7.287	g/VKT	2007-based IVE
	LDGT		8.665	g/VKT	2007-based IVE
	LDDT		1.673	g/VKT	2007-based IVE
	Bus		7.103	g/VKT	2007-based IVE
	Taxi		12.614	g/VKT	2007-based IVE
	Motorcycle		6.780	g/VKT	2007-based IVE

Table S10. Industrial parks transfer from PRD to NPRD during 2008-2014

Park Name	Relocated City*	Industries in the Park
Guangzhou (Meizhou) Industrial Transfer Park	Meizhou	Automobile (motorcycle) Spare Parts, Electronic Information, Applications of Rare Earth (and High-end Pharmaceutical and Health Food Industries)
Guangzhou (Qingyuan) Industrial Transfer Park	Qingyuan	Equipment Manufacturing, Electronic Information and New Material Industry (and New Energy and Biomedical Industry)
Shenzhen (Heyuan) Industrial Transfer Park	Heyuan	Electronic Information, Mechanical Mold and Photovoltaic Industry (and High-tech and New Material of Rare Earth Industry)
Shenzhen (Shanwei) Industrial Transfer Park	Shanwei	Electronic Information, Cloud Computing and New Energy Industry (and Food Processing Industry)
Zhuhai (Yangjiang) Industrial Transfer Park	Yangjiang	Food and Pharmaceuticals, Metal Products Light Emitting Diode and Solar Photovoltaic Industry
Foshan (Yunfu) Industrial Transfer Park	Yunfu	Machinery Manufacturing, Automobile Spare Parts, and Stone Processing Industry
Dongguan (Shaoguan) Industrial Transfer Park	Shaoguan	Equipment Basic Parts and Toys Industry
Zhongshan (Chaozhou) Industrial Transfer Park	Chaozhou	Energy and New Electronic Materials and Equipment Manufacturing Industry
Shantou Industrial Transfer Park	Shantou	Equipment Manufacturing, Energy and Electronic Information Industry (and Textile and Garment Industry)
Huizhou Industrial Transfer Park	Huizhou	Electronic Device, Clothing Processing, New Building Materials Industry

Jiangmen Industrial Transfer Park	Jiangmen	Hardware Machinery and Equipment Manufacturing, Electronic Information and New Fiber Textile Industry
Zhanjiang Industrial Transfer Park	Zhanjiang	Iron and Steel, Petrochemistry and Its Supporting Industries
Maoming Industrial Transfer Park	Maoming	Petrochemistry and It's Upstream and Downstream Industries
Zhaoqing Dawang Industrial Transfer Park	Zhaoqing	Metal Material and Electronic Industry (and Biomedicine and Advanced Machinery and Equipment Industry)
Jieyang Industrial Transfer Park	Jieyang	Machinery and Equipment, Metal Manufacturing and Electronic Information Industry
Dongguan Shilong (Shixing) Industrial Transfer Park	Shaoguan	Distinctive New Material Industry
Dongguan Dongkeng (Lechang) Industrial Transfer Park	Shaoguan	Distinctive Machinery Manufacturing Industry
Daling Mountain of Dongguan (Nanxiong) Industrial Transfer Park	Shaoguan	Fine Chemical Industry
Shenzhen Futian (Heping) Industrial Transfer Park	Heyuan	Watch Manufacturing and Distinctive Telecommunication (and Food and Pharmaceuticals)
Shenzhen Luohu (Heyuan City) Industrial Transfer Park	Heyuan	Electrical Machinery Industry and Distinctive Equipment Manufacturing
Shenzhen Nanshan (Longchuan) Industrial Transfer Park	Heyuan	Distinctive Industry of Electronic and Electrical Appliances
Shenzhen Yantian (Dongyuan) Industrial Transfer Park	Heyuan	New Materials, New Electronic Industry
Dongguan Shijie (Xingning) Industrial Transfer Park	Meizhou	Distinctive Machinery Manufacturing Industry
Dongguan Fenggang (Huidong) Industrial	Huizhou	Machinery and Equipment, Shoemaking Industry

Transfer Park		
Zhongshan Huoju (Yangxi) Industrial Transfer Park	Yangjiang	Distinctive Food and Beverage Industry
Foshan Chancheng (Yangdong Wanxiang) Industrial Transfer Park	Yangjiang	Distinctive Hardware Machinery Industry
Dongguan Chang'an (Yangchun) Industrial Transfer Park	Yangjiang	Distinctive Iron and Steel Industry
Foshan Shunde (Lianjiang) Industrial Transfer Park	Zhanjiang	Distinctive Household Appliance Manufacturing Industry
Shenzhen Longgang (Wuchuan) Industrial Transfer Park	Zhanjiang	Distinctive Light Industry and Electronic Industry
Guangzhou Baiyun Jianggao (Dianbai) Industrial Transfer Park	Maoming	Aquatic Products Processing and Flavor and Fragrance Industry
Dongguan Dalang (Xinyi) Industrial Transfer Park	Maoming	Distinctive Wool Textile Industry (and Arts and Crafts, Metal Products Industry)
Shunde Longjiang (Deqing) Industrial Transfer Park	Zhaoqing	Forestry Chemical Industry
Zhongshan Dachong (Huaiji) Industrial Transfer Park	Zhaoqing	Distinctive Equipment Manufacturing Industry
Foshan Chancheng (Qingxin) Industrial Transfer Park	Qingyuan	Distinctive Architectural Ceramics Industry
Foshan Shunde (Yingde) Industrial Transfer Park	Qingyuan	Equipment Manufacturing, Distinctive Industry of Electronic and Electrical Appliances
Foshan Shunde (Yunfu Xinxingxincheng) Industrial Transfer Park	Yunfu	Distinctive Metal Products Industry

Guangdong Shunde-Qingyuan (Yingde) Economic Cooperation Zone	Qingyuan	Equipment Manufacturing, Household Appliances Characteristic Industry
Jieyang Metal Eco-city	Jieyang	Distinctive Metal Products Industry
Shenzhen Longgang (Zijin) Industrial Transfer Park	Heyuan	Electronic, Electrical and Mechanical Manufacturing
Dongguan Tangxia (Pingyuan) Industrial Transfer Park	Meizhou	Rare Earth New Materials, High-Quality Building Materials, Machinery Manufacturing

*Relocated cities are all in the non-Pearl River Delta (NPRD) region.

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