Supplementary Information for

Refined Estimate of China's CO_2 Emissions in Spatiotemporal Distributions

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Figure S1. Geographical locations and abbreviations for the 31 provinces in China's mainland (Inner Mongolia is also called in Neimeng in China).

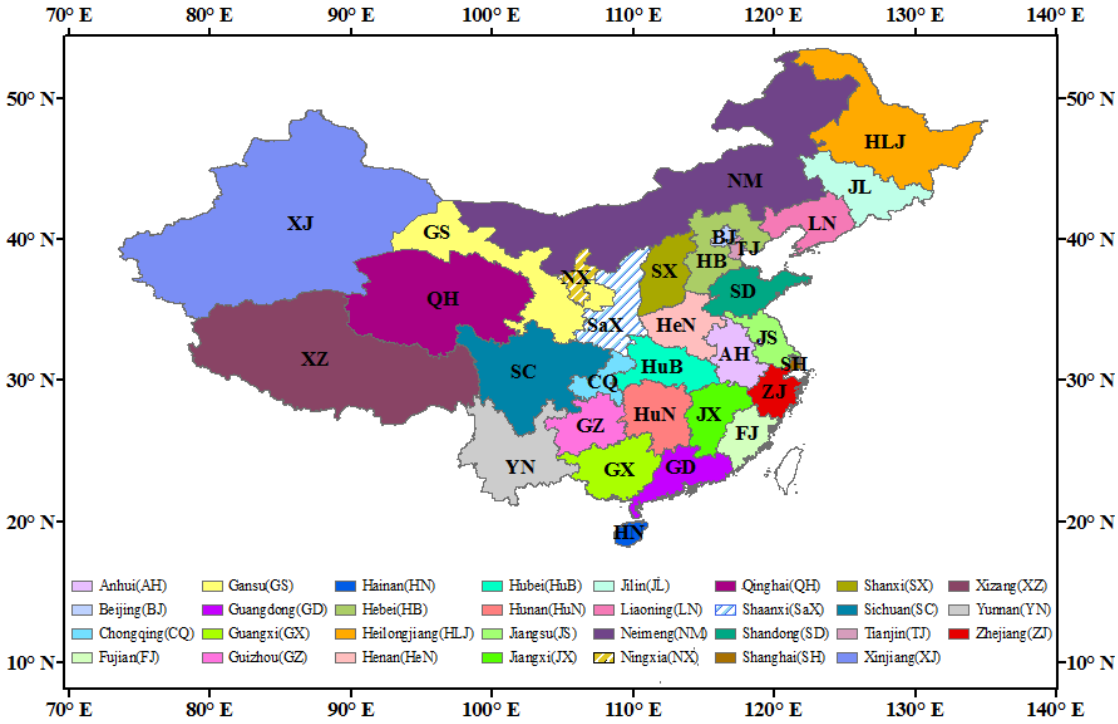
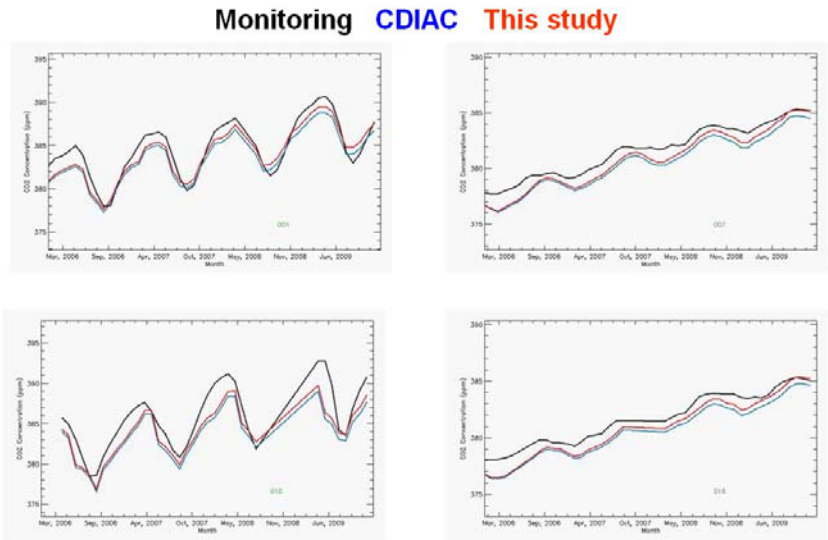
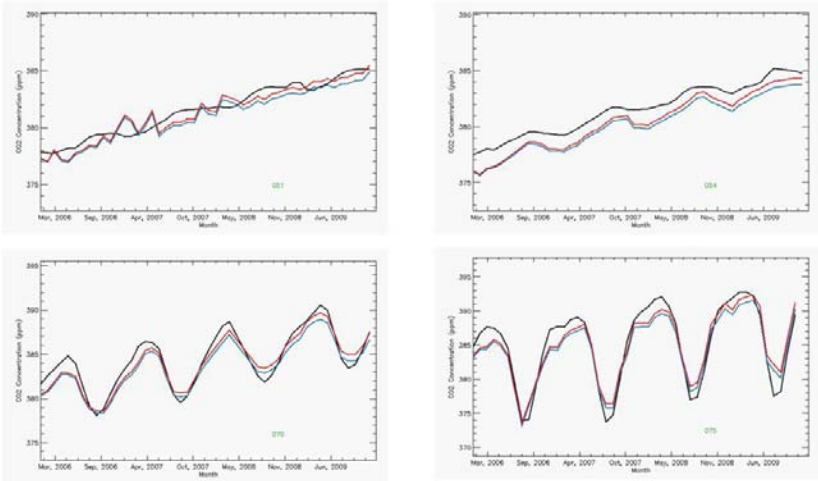


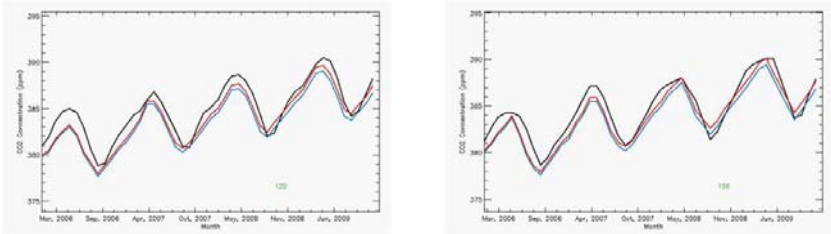
Figure S2. Comparisons between monitoring data and modeling results using CDIAC and our inventory as inputs at various observation sites



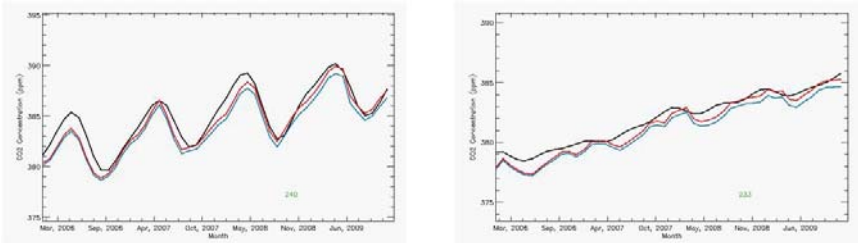
(a) Land sites: ask_01D0, cya_02D0, hdpdta_03C0, maa_02D0



(b) Ocean sites: cgo_01D0, crz_01D0,rpb_01D0, stm_01D0



(c) Aircraft observations:car080_01P2,hil070_01P2



(d) Pacific Ocean ship observations: pocn30_01D1, pocs25_01D1

Figure S3. Spatial distribution ((0.25° resolution)) of China's CO_2 emissions in 2000 and 2005

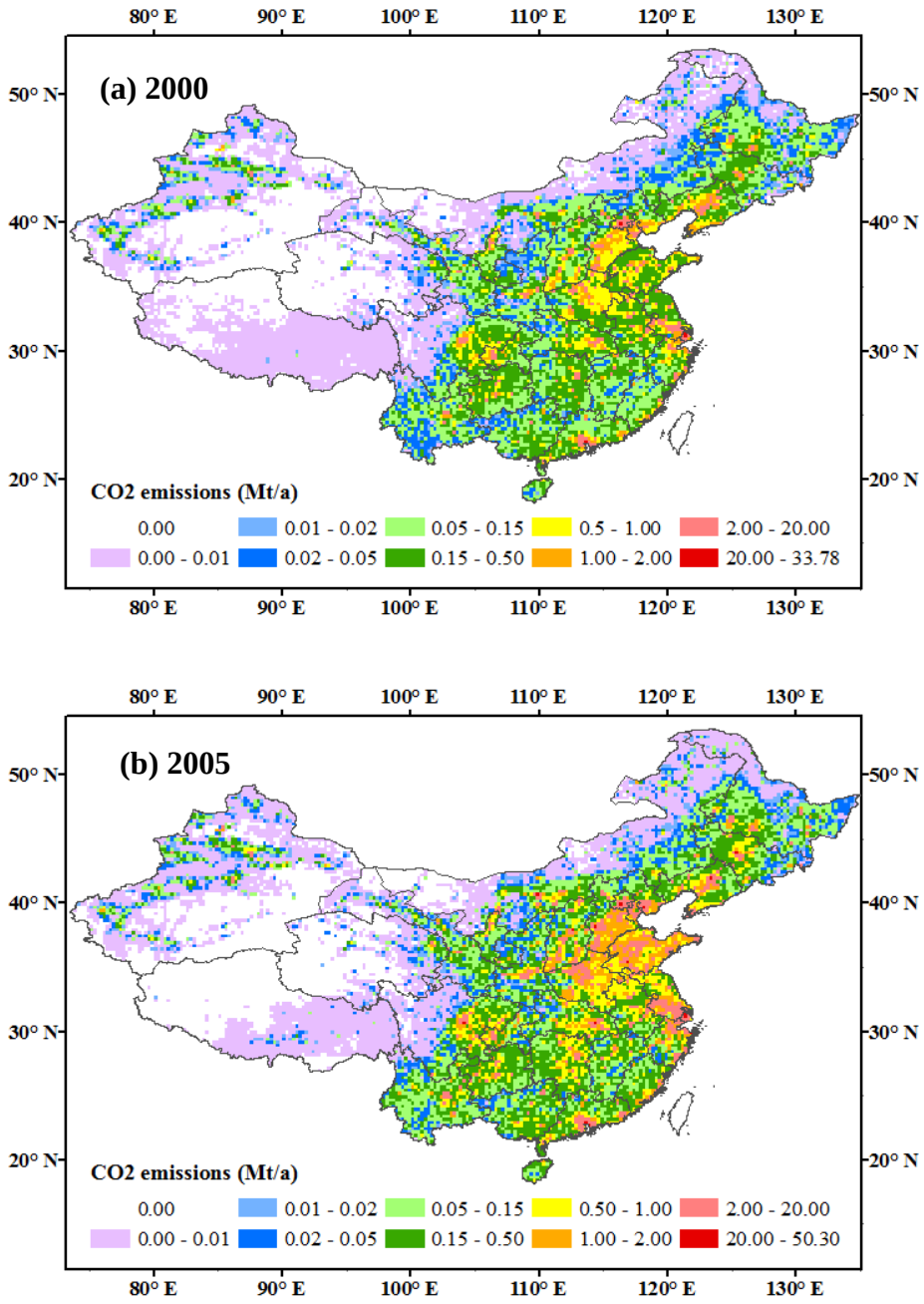


Figure S4. Distribution of ratios between grid-emission fractions (the fraction of each grid emissions to the total emissions) of 2009 and 2000; Ratio of 1 indicates that the grid-emission fractions of 2009 is equal to those of 2000. And ratios larger than 1 indicate that the grid-emission fractions of 2009 is higher than those of 2000, and vice versa, which both reflects great changes in the population and GDP distribution in recent years for the rapid urbanization.

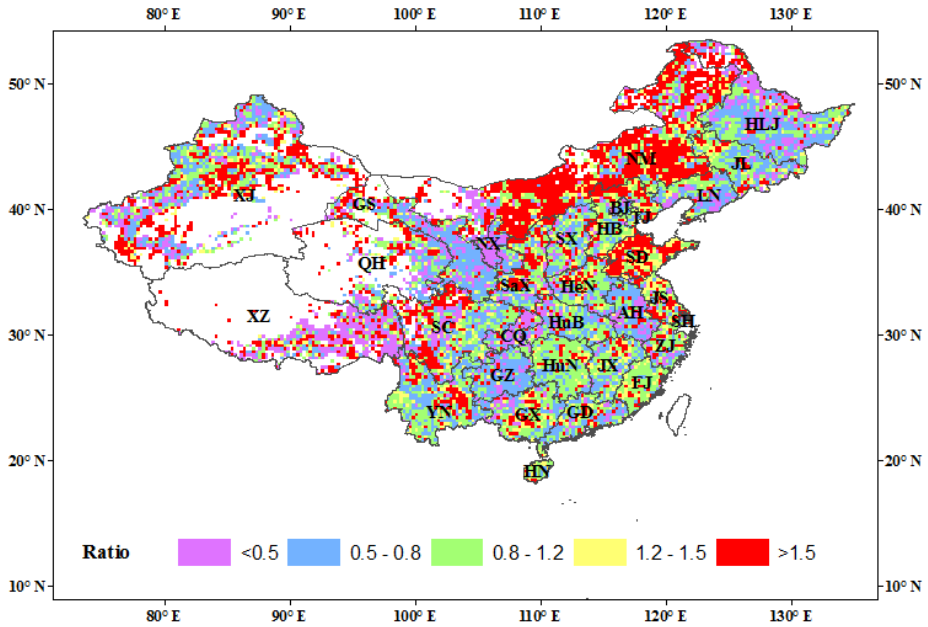


Figure S5. Monthly variations of industry added value in China from 2001 to 2009

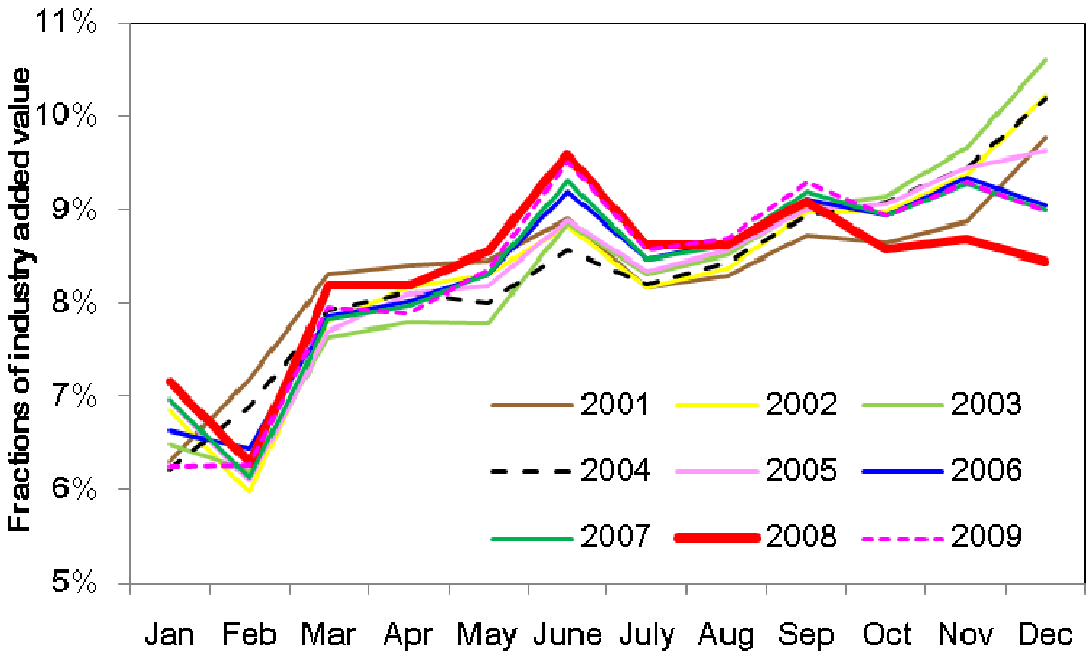


Figure S6. Four satellite images are typical examples of power stations found on Google Earth.

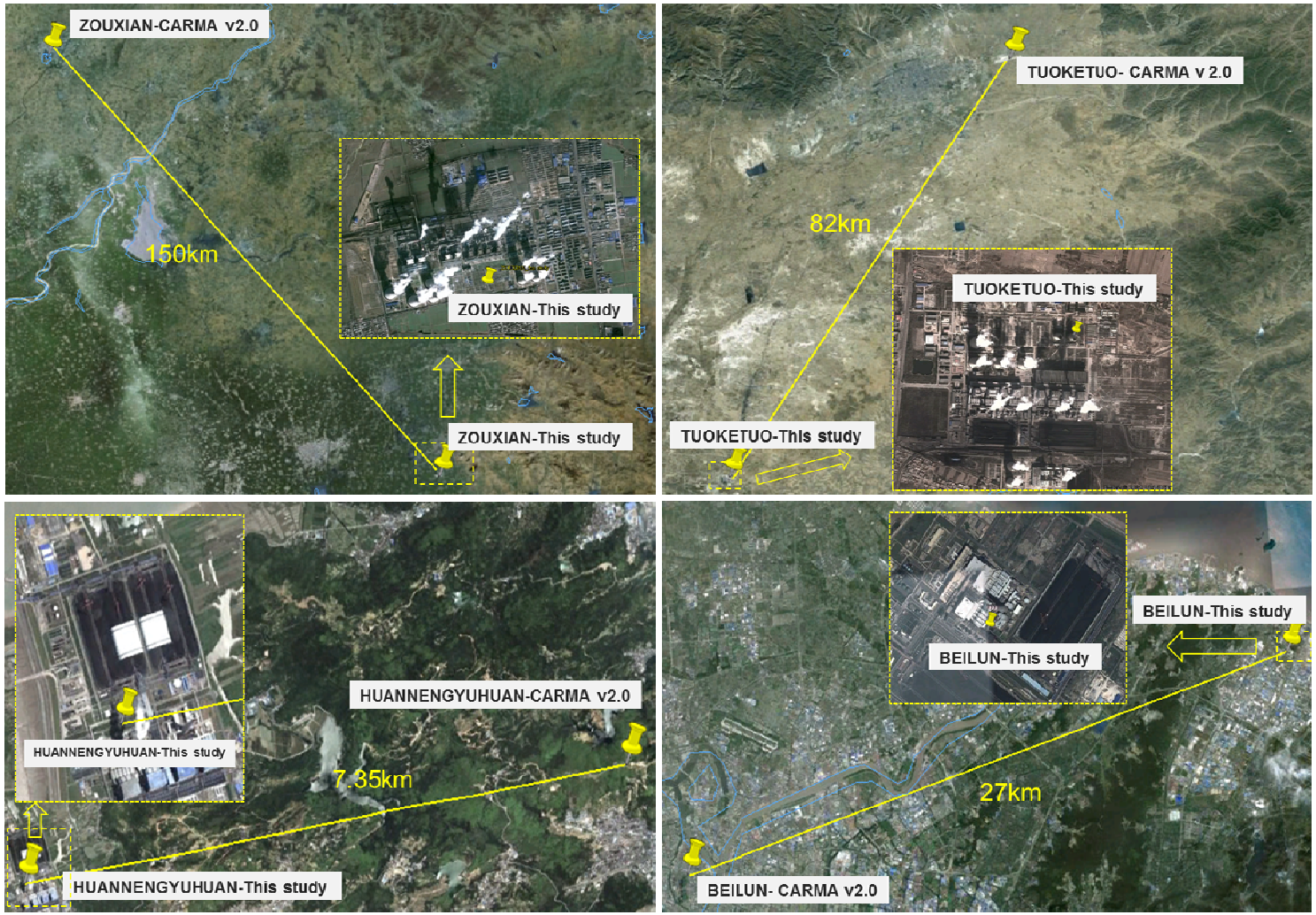


Table S1. China's CO_2 emission factors (EF) with probability distributions (90% CIs are given for all distributions)

Fuel	Carbon oxidation rate	Carbon oxidation rate	Original data source
Raw coal	0.93 (0.89-0.98);	Gamma	IPCC(2006); Cai et al. (2009); Zhao et al (2012)
Cleaned coal	0.96 (0.95-0.98);	Weibull	
Other washed coal	0.96 (0.92-1);	Triangular	
Briquettes	0.90 (0.89-0.98);	Weibull	IPCC(2006);
Coke	0.93 (0.89-1);	Triangular	
Coke Oyen Gas	0.99 (0.98-1);	Triangular	
Other Gas	0.99 (0.98-1);	Triangular	
Natural Gas	0.99 (0.98-0.995);	Normal	Zhao et al. (2012)
Natural Gas Liquids	0.98 (0.96-0.995);	Lognormal	Cai et al. (2009)
Crude Oil	0.98 (0.92-0.99);	Lognormal	IPCC(2006); Cai et al. (2009); Zhao et al (2012)
Gasoline	0.98 (0.92-0.99);	Lognormal	IPCC(2006); Zhao et al (2012);Yan and Crookes (2009); Cai et al. (2009); Ou et al. (2010);
Kerosene	0.98 (0.92-0.99);	Lognormal	IPCC(2006); Zhao et al (2012);Yan and Crookes (2009); Cai et al. (2009); Ou et al. (2010);
Diesel Oil	0.98 (0.92-0.99);	Lognormal	IPCC(2006); Zhao et al (2012);Yan and Crookes (2009); Cai et al. (2009); Ou et al. (2010);
Fuel Oil	0.98 (0.96-1);	Triangular	IPCC(2006); Zhao et al (2012);Yan and Crookes (2009); Cai et al. (2009); Ou et al. (2010);
Liquefied Petroleum Gases	0.98 (0.96-1);	Triangular	
Refinery Gas	0.98 (0.96-1);	Triangular	
Other Petroleum Products	0.98 (0.96-1);	Triangular	
Process	**EF (Range)**	**Distribution**	**Original data source**
Cement process (kg CO_2/t-clinker)	0.549 (0.52-0.578)	Weibull	IPCC(2006); Lei et al. (2011); Cui and Liu (2008)
Iron & steel (kg CO_2/t-steel)	0.20 (0.15-0.26)	Normal	Shangguan et al. (2010); Jiang et al. (2009); CISA (2010)
Al process(kg CO_2/t-Al)	1.65 (0.816-2.384)	Normal	IPCC(2006);
Glass process(kg CO_2/t-Glass)	0.20 (0.102-0.298)	Normal	IPCC(2006);

Table S2. Spatial proxies used for allocating provincial emissions

Emission sector	Type of activity data	Proxy
Industrial energy consumption	Fuel consumption	GDP
Transportation	Fuel consumption	Population
Other energy consumption	Fuel consumption	Population
Industry process	Industrial product output	GDP

Table S3. CO_2 emissions from various types of fossil fuels in this study and their differences with other datasets, million tons

Year	Coal				Oil				Gas			
	Ours-IEA	Ours-EIA	Ours-CDIAC	Ours	Ours-IEA	Ours-EIA	Ours-CDIAC	Ours	Ours-IEA	Ours-EIA	Ours-CDIAC	Ours
2000	-42	234	-7	2391	-6	-88	-94	555	16	9	-1	59
2001	97	299	126	2557	10	-74	-76	584	19	14	1	68
2002	154	83	234	2796	7	-72	-76	621	23	16	2	75
2003	80	-115	-91	3174	19	-25	-77	692	23	21	23	84
2004	49	-417	-90	3748	-2	-69	-113	781	33	29	32	104
2005	317	-45	222	4487	145	66	49	955	34	25	32	117
2006	311	170	232	4949	167	103	55	1031	47	37	44	148
2007	371	214	398	5373	205	143	94	1102	61	52	60	190
2008	274	52	554	5706	203	135	93	1130	77	74	75	225
2009	283	-474	0	6003	243	131	0	1191	104	97	0	268

Table S4. Detailed EFs of various energy types and industrial products

Fuel type	Carbon content (kg/GJ) [1]	Carbon oxidation rate[2]	Emission rate (95% lower) (kg-CO_2/TJ)	Net calorific value (TJ/Gg) [1]	Emission factor (ton-CO_2/ton)
Crude Coal	25.8	93%	81189	20.9	1.70
Washed Coal	25.8	96%	83808	26.3	2.21
Other Washed Coal	25.8	96%	83808	8.4	0.70
Briquette	26.6	90%	78570	20.9	1.64
Coke	29.2	93%	89001	28.4	2.53
Coke Oven Gas	12.1	99%	36927	16726 [3]	6.18 [4]
Natural Gas	15.3	99%	53757	38931 [3]	20.93[4]
LNG	17.5	98%	57134	44.2	2.53
Crude Oil	20.0	98%	69678	41.8	2.91
Gas	18.9	98%	66150	43.1	2.85
Kerosene	19.5	98%	68306	43.1	2.94
Diesel	20.2	98%	71148	42.7	3.03
Fuel Oil	21.1	98%	73990	41.8	3.09
LPG	17.2	98%	60368	50.2	3.03
Other petroleum products	20.0	98%	73990	41.8	3.09

Table S5. Details of large point sources for 31 provinces

Province	2000				2005				2009				Annual average growth rate	Annual average growth rate	Percent of emissions from whole society		
	Count		Emissions (1000t/a)		Count		Emissions (1000t/a)		Count		Emissions (1000t/a)						
	PP[1]	CP[2]	PP	CP	PP	CP	PP	CP	PP	CP	PP	CP	10 FYP	11 FYP	2000	2005	2009
Anhui	8	-	1990.1	-	16	13	4672.56	1417.8	28	15	9039.06	2297.98	25.07%	16.81%	13.52%	28.46%	35.03%
Beijing	5	-	1306.4	-	5	3	1748.84	129.27	7	3	1814.6	178.126	7.53%	1.49%	15.22%	16.90%	17.17%
Fujian	4	-	1192.1	-	5	4	3593.72	170.02	10	5	6289.71	333.465	25.85%	15.18%	19.10%	28.33%	33.65%
Gansu	6	-	1060.5	-	9	2	2607.61	92.878	10	6	3365.37	329.816	20.56%	8.16%	15.66%	26.70%	29.86%
Guangdong	18	-	5983.2	-	32	11	12804.3	662.35	20	23	7437.96	1749.48	17.62%	-9.12%	27.64%	37.35%	19.53%
Guangxi	2	-	298.03	-	5	6	1412.92	250.72	9	7	2746.55	479.4	41.05%	18.00%	4.79%	14.80%	19.45%
Guizhou	7	-	1778	-	11	0	5260.29	0	16	0	8264.95	0	24.23%	11.96%	17.69%	30.97%	36.91%
Hainan	1	-	195.68	-	2	0	527.075	0	2	1	739.011	72.904	21.92%	11.41%	17.79%	25.79%	25.93%
Hebei	17	-	6058.9	-	21	9	10376.9	283.38	26	16	12234.6	1240.31	11.96%	6.03%	22.35%	21.20%	20.91%
Henan	16	-	4419.2	-	32	8	10183.4	401.11	39	32	14408.2	1080.99	19.09%	9.99%	20.41%	25.37%	28.00%
Heilongjiang	4	-	1600.1	-	11	3	4535.79	95.891	12	3	4922.96	133.544	23.68%	2.22%	10.73%	23.53%	20.19%
Hubei	8	-	1754.6	-	12	6	4350.77	303.33	14	12	4877.85	1894.72	21.54%	9.83%	13.00%	21.52%	22.36%
Hunan	6	-	1202.9	-	8	4	3925.43	160.26	13	8	5154.08	454.381	27.70%	8.24%	12.63%	19.09%	20.64%
Jilin	7	-	1770.6	-	7	4	2362.67	252.43	11	5	3050.4	368.443	8.11%	6.93%	17.83%	16.25%	16.31%
Jiangsu	22	-	6622.8	-	35	21	14331.7	990.16	41	25	17758.9	1328.16	18.26%	5.65%	29.65%	35.65%	34.07%
Jiangxi	7	-	1325	-	9	12	3128.57	467.81	11	14	3894.18	772.524	22.10%	6.73%	22.21%	33.58%	30.15%
Liaoning	15	-	4218.5	-	17	6	6904.27	130.49	21	11	8732.68	545.749	10.77%	7.17%	18.75%	21.17%	21.18%
Inner Mongolia	10	-	3236.1	-	18	4	9055.46	136.69	28	8	12398.5	327.236	23.22%	8.47%	27.62%	33.69%	26.42%
Ningxia	4	-	1088.4	-	4	2	2347.56	61.24	10	4	3785.1	488.352	17.22%	15.41%	19.75%	36.60%	43.94%

Province	2000				2005				2009				Annual average growth rate	Annual average growth rate	Percent of emissions from whole society		
	Count		Emissions (1000t/a)		Count		Emissions (1000t/a)		Count		Emissions (1000t/a)						
	PP[1]	CP[2]	PP	CP	PP	CP	PP	CP	PP	CP	PP	CP	10 FYP	11 FYP	**2000**	**2005**	**2009**
Qinghai	1	-	196.64	-	1	0	425.341	0	2	1	701.437	37.9652	16.68%	14.82%	12.74%	16.68%	18.50%
Shandong	21	-	7160.1	-	35	30	13997.4	1908.5	46	37	19079.1	1712.26	17.31%	6.93%	29.50%	25.51%	26.02%
Shanxi	11	-	4017.7	-	20	3	9725.24	81.459	26	2	12590.9	95.004	19.54%	6.65%	23.38%	29.74%	31.26%
Shaanxi	6	-	1485.4	-	9	5	3055.44	204.18	13	7	5546.37	683.199	17.02%	17.58%	20.52%	23.08%	29.49%
Shanghai	9	-	3891.6	-	12	1	6028.28	36.332	12	5	5503.49	58.6872	9.28%	-2.14%	30.43%	34.97%	27.65%
Sichuan	1	-	161.39	-	9	6	2526.19	551.32	10	6	3038.4	270.076	80.33%	1.83%	1.21%	14.29%	10.04%
Tianjin	5	-	1557.8	-	8	3	3130.99	54.788	9	4	3103.95	64.6646	15.38%	-0.13%	24.24%	33.08%	25.07%
Xinjiang	2	-	534.39	-	5	2	1168.55	77.441	6	7	1705.22	508.566	18.45%	15.45%	6.72%	9.90%	11.97%
Xizang	0	-	0	-	0	0	0	0	0	0	0	0	0.00%	0.00%	0.00%	0.00%	0.00%
Yunnan	3	-	577.69	-	5	2	2263.33	118.84	10	2	4331.4	91.1349	32.76%	16.73%	7.70%	15.35%	20.86%
Zhejiang	11	-	3718	-	18	36	7257.85	1689.1	22	53	12252.9	2756.67	19.20%	13.81%	26.47%	34.14%	41.90%
Chongqing	3	-	921.89	-	3	7	1441.71	267.79	5	10	2063.24	506.616	13.15%	10.73%	11.89%	18.65%	17.65%
Total	**240**	**-**	**71324**	**-**	**384**	**213**	**155150**	**10996**	**489**	**332**	**200831**	**20860**	**18.43%**	**7.48%**	**19.80%**	**26.04%**	**25.68%**

1. PP means power plants;
2. CP means cement plants.

Table S6. Abbreviations of the top 20 power plants in CARMA v2.0

Plant Id	Company	Name
51316	HUADIAN POWER INTL CORP	ZOUXIAN
18676	HUANENG POWER INTERNATIONAL	HUANENG YUHUAN
46619	DATANG INTL POWER GEN CO	TUOKETUO-1
3846	ZHEJIANG PROVINCIAL ELEC POWER	BEILUNGANG
48705	SHENERGY COMPANY LTD	WAIGAOQIAO
44234	GUOHUA ELECTRIC POWER CORP	TAISHAN
44250	XISHAN COAL AND ELECTRICITY	TAIYUAN
51300	INNER MONGOLIA ELEC POWER CORP	YUANBAOSHAN
18663	HUANENG POWER INTERNATIONAL	HUANENG LUOHUANG
25221	CITIC PACIFIC LTD	LIGANG
10692	HUANENG POWER INTERNATIONAL	DEZHOU (HUALU)
51158	CHEUNG KONG INFRASTRUCTURE	ZHUHAI GZP
20287	CHINA GUODIAN GROUP CORP	JIANBI
34693	CHINA POWER INTL DEVELOP LTD	PINGWEI
50575	CHINA POWER INTL DEVELOP LTD	YAOMENG
40832	NORTH CHINA GRID CO LTD	SHALINGZI
51229	DATANG INTL POWER GEN CO	ZHANGJIAKOU
18542	FPC HUAYANG ZHANGZHOU POWER	HOUSHI
50558	CHINA RESOURCES POWER HOLDINGS	YANGZHOU-2
16870	CHINA HUADIAN GROUP CORP	HARBIN-3
31278	SHENHUA GROUP CORP LTD	NINGHAI
40855	CHINA HUANENG GROUP CORP	SHANGDU
50534	CHINA DATANG CORP	YANGCHENG
52280	CHINA GUODIAN CORP	DATONG-2
10083	CHINA HUANENG GROUP CORP	DALATE
18674	CHINA HUANENG GROUP CORP	HUANENG YINGKOU
49156	CHINA DATANG CORP	WEIHE-2
18667	CHINA HUANENG GROUP CORP	HUANENG SHANG'AN
20304	CHINA GUODIAN CORP	JIANGYIN
16146	CHINA HUADIAN GROUP CORP	GUANGAN

Table S7. Comparison of the top 20 power plants in CARMA v2.0 with this study

Plant Id	Emission Difference	Distance (km)
51316	128%	150
18676	162%	7
46619	15%	83
3846	36%	27
48705	27%	0
44234	11%	45
44250	96%	30
51300	98%	32
18663	49%	19
25221	36%	1037
10692	46%	3
51158	105%	50
20287	74%	14
34693	145%	10
50575	115%	2
40832		-
51229	18%	18
18542	-8%	53
50558	32%	12
16870	86%	25