Supplement of Earth Syst. Sci. Data, 13, 1073–1088, 2021
https://doi.org/10.5194/essd-13-1073-2021-supplement

Open Access Earth System Science Data

Supplement of

A comparative study of anthropogenic CH_4 emissions over China based on the ensembles of bottom-up inventories

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Table S1 Source categories for each sector among different inventories.

Sector categories	PKU	CEDS	EDGAR	GAINS	REAS	NCCC
Agriculture	Rice cultivation	Rice cultivation	Agricultural soils	Agriculture	Rice cultivation	Rice cultivation
	Livestock	Enteric fermentation	Agricultural waste burning	Burning of crop residues	Enteric fermentation	Enteric fermentation
		Manure management	Enteric fermentation		Manure management	Manure management
			Manure management			
Energy	Coal mining	Fugitive-solid-fuels	Power industry	Energy production	Fugitive_coal	Coal mining
			Oil refineries and			
	Fuel combustion	Fugitive-other-energy	Transformation industry	Domestic	Fugitive_gas	Fuel combustion
	Fugitive_oil_gas	Fugitive-petr-and-gas	Combustion for manufacturing	Transportation	Fugitive_oil	Fugitive_oil_gas
		Energy-transformation	Road transportation	Other mobile	International navigation	
			Railways, pipelines, off-road			
		Stationary_RCO	transport		Other_transport	
		Chemical-industry	Shipping		Power_plant_point	
		Metals-industry	Energy for buildings		Road_transport	
		Transportation	Fuel exploitation COAL		Aviation	
		Fossil-fuel-fires	Fuel exploitation OIL		Domestic	
			Fuel exploitation GAS			
			Fossil Fuel Fires			
Waste treatment	Landfills	Soild-waste-disposal	Solid waste landfills	Waste	Waste	Landfills
	Wastewater	Wastewater-handling	Solid waste incineration			Wastewater

	Waste-incineration	Waste water handling	

Table S1 Continued.

Sector categories	EPA	FAO	GMB_BU	CHRED	Huang et al.(2019)	Yue et al.(2012)	Zhang et al.(2014;2016;2018)
Agriculture	Rice cultivation Enteric fermentation Manure management	Rice cultivation Enteric fermentation Manure management Burning of crop residues and savanna	Rice cultivation Enteric fermentation Manure management	Rice cultivation Enteric fermentation Manure management Burning of crop residues	Rice cultivation Enteric fermentation Manure management Burning of crop residues	Rice cultivation Enteric fermentation Manure management	Rice cultivation Enteric fermentation Manure management Burning of crop residues
Energy	Coal mining Fugitive_oil_gas	energy	Coal mining Gas, Oil and Industry	Coal mining	Coal mining Fugitive_oil_gas	Coal mining	Coal mining Fugitive_oil_gas Fuel combustion Bio-fuel combustion
Waste treatment	Landfills Wastewater	Waste	Landfills and waste	Landfills Wastewater	Landfills Industrial wastewater Domestic sewage	Waste	Landfills Industrial wastewater Domestic sewage

Table S2 Sectoral and sub-sectoral CH_4 emissions of China among different inventories in 2010.

Sector	PKU	CEDS	EDGAR	NCCC	FAO	GAINS	Zhang et al. (2016)	Zhang et al. (2017)	Zhu et al. (2017)	Sheng et al. (2019)	Mean	SD
China	**44.80**	**47.59**	**57.46**	**53.69**	**51.30**	**47.64**	**44.35**	**NA**	**NA**	**NA**	**49.55**	**4.47**
Agriculture	18.75	16.36	23.29	22.43	14.10	16.18	16.02	20.56	NA	NA	18.46	3.13
Livestock	11.41	11.11	9.38	13.38	8.86	NA	10.04	12.37	NA	NA	10.94	1.50
Rice cultivation	7.34	5.25	13.90	8.73	5.25	NA	5.61	8.19	NA	NA	7.75	2.83
Energy	21.75	20.59	23.74	26.86	26.80	25.95	22.10	NA	NA	NA	23.97	2.40
Coal mining	18.97	17.78	17.31	22.87	NA	NA	19.32	NA	16.00	15.20	18.21	2.34
Other	2.78	2.81	6.43	3.99	NA	NA	2.77	NA	NA	NA	3.76	1.41
Waste treatment	4.29	10.64	10.43	4.40	10.40	5.51	6.23	NA	NA	NA	7.42	2.73
Wastewater	2.27	7.78	7.68	2.19	NA	NA	2.28	NA	NA	NA	4.44	2.68
Landfills	2.02	2.87	2.75	2.21	NA	NA	3.95	NA	NA	NA	2.76	0.68

Table S3 Spatial proxy datasets and resolutions used by different inventories.

Sub-sector	Inventory	Proxy data	Spatial resolution	References
Livestock	PKU	Gridded data for numbers of animals in 2005	1 km x 1 km	Robinson et al. (2011)
	EDGAR	Animals: buffaloes, cattles, goats, pigs, sheeps. FAO Geonetwork (2014): http://livestock.geo-wiki.org/ and with for buffaloes: http://www.fao.org/AG/AGAInfo/resources/en/glw/GLW_dens.html	0.1° x 0.1°	livestock: http://livestock.geo-wiki.org/; buffaloes: http://www.fao.org/AG/ AGAInfo/resources/en/glw/GLW_dens.html
	Lin	County data: diary and non-diary cattles, buffaloes, goats, sheeps, pigs; Land use data for grassland and rural settlements	10 km x 10 km	Lin et al. (2011)
Rice cultivation	PKU	Gridded harvested area of rice	0.083° x 0.083°	Monfreda et al. (2008)
	EDGAR	Ramankutty (2008) agricultural land and crop type mask		Ramankutty et al. (2008)
	Zhang	Process-based model: Gridded harvested area of rice	0.083° x 0.083°	Zhang et al. (2017)
Coal exploitation	PKU	Annual production from 4264 coal production sites	0.1° x 0.1°	Liu et al. (2015)
	MIT	More than 10000 coal mines in China for 2011	0.25° x 0.25°	Sheng et al. (2019)
	EDGAR	Brown and hard coal. USGS (2014); EPRTRv4.2 (2012); Liu et al. (2015): Combining USGS coal mines (https://www.usgs.gov/) and EPRTRv4.2 for European mines (http://prtr.ec.europa.eu) and Global Energy Observatory (http://globalenergyobservatory.org) and China coal mine data from Liu et al. (2015)	0.1° x 0.1°	Janssens-Maenhout et al. (2019) In-house EDGAR proxy based on EPRTR (http://prtr.ec.europa.eu) and USGS (https://www.usgs.gov/) and Global Energy Observatory (http://globalenergyobservatory.org/)
	Harvard	EDGAR v4.3.2 emission grid maps for 2012	0.1° x 0.1°	Janssens-Maenhout et al. (2019)

Oil and gas systems	PKU	EDGARv42 gridded 1B2a subcategory	0.1° x 0.1°	EDGARv42; Schwietzke et al. (2014)
	EDGAR	In-house EDGAR proxy based on https://www.ngdc.noaa.gov/eog/viirs.html; World Port Index (PUB 150) (http://msi.nga.mil/MSISiteContent/StaticFiles/NAV_PUBS/WPI/Pub150bk.pdf)	0.1° x 0.1°	Janssens-Maenhout et al. (2019)
	Harvard	Global distributions of oil, gas wells, and pipelines	0.1° x 0.1°	Global distributions of oil and gas wells (Enverus (2017); Rose (2017)), pipelines (EIA (); Petroleum Economist Ltd. (2010); (Sheng et al., 2017); Sabbatino et al. (2017)), and midstream facilities Sabbatino et al. (2017)
Landfills	PKU	Gridded total population in 2005 and 2010	1 km x 1 km	Huang et al. (2014)
	EDGAR	In-house EDGAR proxy based on EPRTRv4.2 European landfills (http://prtr.ec.europa.eu) and CEC (http://takingstock.cec.org/) (gapfilled with urban population)	0.1° x 0.1°	In-house EDGAR proxy based on EPRTR (http://prtr.ec.europa.eu) and CEC (http://takingstock.cec.org/)
Wastewater	PKU	Gridded total population in 2005 and 2010	1 km x 1 km	Huang et al. (2014)
	EDGAR	In-house EDGAR proxy based on CIESIN GWPv3 population and settlements map (5 year timesteps from 1990 onwards) http://sedac.ciesin.columbia.edu/(rural pop.=total pop.–urban pop.)	0.1° x 0.1°	In-house EDGAR proxy based on EPRTR (http://prtr.ec.europa.eu) and CEC (http://takingstock.cec.org/) ; In-house EDGAR proxy based on http://sedac.ciesin.columbia.edu/

Table S4 Emission factors for different source categories among different inventories.

Major sectors	Items	IPCC	EDGAR	PKU	FAO	NCCC	GAINS	(Huang et al., 2019)	(Zhang and Chen,	(Zhang et al.,

								2014)	1999)
Energy	Coal mining_underground (m3/t)	18.0	10.0	8.23(5.58-20.35)	8.89	9.3	4.53-21.83	4.53-21.83	11.0
	Coal mining_underground_post (m3/t)	2.5	0.9	1.18-1.30		2.5	NA	1.13-3.02	1.8
	Coal mining_open (m3/t)	1.2	NA	2.5		NA	2.5	2.5	2.5
	Coal mining_open_post (m3/t)	0.1	NA	NA		NA	NA	0.1	0.1
	Oil (kg/t)	4.9	96.4(kg/TJ)*	3.3			0.4	1.0	0.4
	Gas (%)	2.0	144.3(kg/TJ)*	2.0-4.6			0.3	0.6	0.3
Agriculture	Dairy cattle_Enteric_Fermentation (kg/head/year)	68.0	77.2	54(46-64)	68.0	56.0	65.3	65.3	52.7
	Non-dairy cattle_Enteric_Fermentation (kg/head/year)	47.0	64.2	53(39-53)	47.0	44.0	54.2	54.2	40.5
	Buffalo_Enteric_Fermentation (kg/head/year)	55.0	55.0	57(47-62)	55.0	57.0	72.9	72.9	53.5
	Sheep_Enteric_Fermentation (kg/head/year)	5.0	5.0	5(5-7)	5.0	5.0	5.3	5.3	5.4
	Goats_Enteric_Fermentation (kg/head/year)	5.0	5.0	4(4-6)	5.0	NA	4.6	4.6	5.4
	Swine_Enteric_Fermentation (kg/head/year)	1.0	1.0	1.0	1.0	NA	1.0	1.0	NA
	Dairy cattle_Manure (kg/head/year)	10.0	11.5	18(9-26)	9.1	16.0		9.0	
	Non-dairy cattle_Manure (kg/head/year)	1.0	1.0	1.0	1.0	1.0		0.9	
	Buffalo_Manure (kg/head/year)	1-2	1.3	1-2	1.0	2.0		1.8	
	Sheep_Manure (kg/head/year)	0.10-0.15	0.12	0.10-0.15	0.1	0.2		0.1	
	Goats_Manure (kg/head/year)	0.11-0.17	0.13	0.11-0.17	0.1	NA		0.1	
	Swine_Manure (kg/head/year)	2-5	2.4	2-5	2.0	NA		3.1	
	Rice_High (g/m2/d)	0.1	1.4	0.3	0.21	0.1	NA	0.6	0.0
	Rice_Low g/m2/d	0.3	0.1	0.2	0.005	0.1	NA	0.1	0.6
Waste	Landfill_EF (%(t/t))	15.0	15.0				NA	2.1	3.2
	Landfill_MCF	0.4-1.0		0.4-1.0				0.7-0.95	
	Waste water_domestic sewage	0.2	0.2	0.2			0.2	0.2	NA

Waste water_industrial wastewater	0.5	0.5	0.5		0.5	0.5	NA

*Implied EF for energy (combustion+fuel exploitation) in EDGAR

Table S5 Emission factors for coal exploitation at the province-level

Province	Coal mining from underground coal mines(m3/ton) (Peng et al. (2016); Zheng et al. (2006))			Coal exploitation (m3/ton) (Sheng et al. (2019))						Coal mining from underground coal mines(m3/ton) (Zhu et al. (2017))				
	Mean	1994	2000	Mean	Uncertainty (%)	Low	Uncertainty (%)	High	Uncertainty (%)	2006	2007	2008	2009	2010
Beijing	5.58	4.18	6.97	1.43	0.48	1.43	0.48	NA	NA	0.74	0.74	0.74	0.74	0.74
Hebei	5.58	4.18	6.97	9.74	0.87	2.88	0.74	16.60	1.00	4.89	4.74	4.60	4.47	4.34
Shanxi	5.58	4.18	6.97	12.70	0.67	3.34	0.69	22.05	0.65	6.48	6.49	6.49	6.50	6.51
Inner Mongolia	5.99	6.00	5.97	10.01	0.80	1.45	1.00	18.56	0.59	0.72	0.75	0.77	0.79	0.82
Liaoning	13.08	11.75	14.40	6.24	1.00	0.46	1.00	12.01	1.00	13.28	12.99	12.70	12.42	12.14
Jilin	13.08	11.75	14.40	8.64	0.42	5.48	0.46	11.80	0.38	6.86	6.71	6.57	6.43	6.29
Heilongjiang	13.08	11.75	14.40	12.02	0.65	3.51	0.66	20.53	0.64	10.04	10.77	11.57	12.42	13.33
Jiangsu	5.84	5.46	6.22	5.02	0.60	2.70	0.73	7.34	0.47	5.22	5.06	4.90	4.75	4.60
Anhui	5.84	5.46	6.22	7.25	0.58	3.87	0.43	10.62	0.73	26.57	25.55	24.57	23.62	22.71
Fujian	5.84	5.46	6.22	4.02	0.42	4.02	0.42	NA	NA	0.74	0.74	0.74	0.74	0.74
Jiangxi	5.84	5.46	6.22	11.28	0.39	6.14	0.30	16.42	0.48	14.68	14.05	13.45	12.88	12.33
Shandong	5.58	4.18	6.97	5.83	0.57	1.93	0.71	9.73	0.42	0.97	1.00	1.02	1.05	1.08
Henan	7.51	7.19	7.83	8.02	0.61	3.41	0.61	12.63	0.61	13.48	13.42	13.36	13.30	13.24
Hubei	7.51	7.19	7.83	11.55	0.47	5.04	0.41	18.05	0.52	6.29	6.48	6.68	6.88	7.09
Hunan	7.51	7.19	7.83	17.00	0.40	6.42	0.31	27.57	0.49	12.12	11.77	11.43	11.10	10.78

Guangxi	7.51	7.19	7.83	13.82	0.27	5.52	0.45	22.12	0.08	1.79	1.51	1.28	1.08	0.91
Chongqing	20.35	19.02	21.68	17.73	0.41	6.65	0.26	28.80	0.56	31.89	32.14	32.39	32.64	32.89
Sichuan	20.35	19.02	21.68	19.40	0.43	6.50	0.34	32.29	0.51	12.56	12.58	12.59	12.61	12.62
Guizhou	20.35	19.02	21.68	19.48	0.40	7.66	0.24	31.30	0.56	27.75	27.19	26.63	26.09	25.56
Yunnan	20.35	19.02	21.68	18.09	0.47	6.09	0.30	30.09	0.63	7.43	7.60	7.78	7.97	8.15
Shaanxi	5.99	6.00	5.97	12.26	0.81	2.46	0.84	22.06	0.78	6.36	5.37	4.54	3.83	3.24
Gansu	5.99	6.00	5.97	7.32	0.30	2.39	0.52	12.25	0.08	1.92	1.92	1.92	1.92	1.92
Ningxia	5.99	6.00	5.97	16.44	0.85	1.71	1.00	31.16	0.69	8.99	8.99	8.99	8.99	8.99
Xinjiang	5.99	6.00	5.97	8.33	0.51	2.92	0.54	13.73	0.47	3.14	3.14	3.14	3.14	3.14

Table S6 Emission factors for manure management (kg head^{-1} yr^{-1}).

Category	CCCCS (2000)				IPCC (2006)/Peng et al. (2016)			Zhou et al. (2007)
	Cool (MAT≤ 14C°)	Temperate (15≤MAT ≤25C°)	Warm (MAT≥ 26C°)	Average	Cool	Temperate	Warm	
Non-dairy cattle	0.65	0.92	1.97	0.77	1	1	1	0.92
Dairy cattle	7.65	16.36	26.17	8.87	9–12	13–26	28–31	8.95
Buffalo	0.92	1.07	2.35	1.07	1	2	2	1.8
Sheep	0.10	0.15	0.20	0.10	0.1	0.15	0.2	0.1
Goats	0.11	0.17	0.22	0.13	0.11	0.17	0.22	0.13
Pigs	1.26	3.74	7.09	3.05	2	3–6	6–7	1.53

Fig. S1 Province names and their geographical locations.

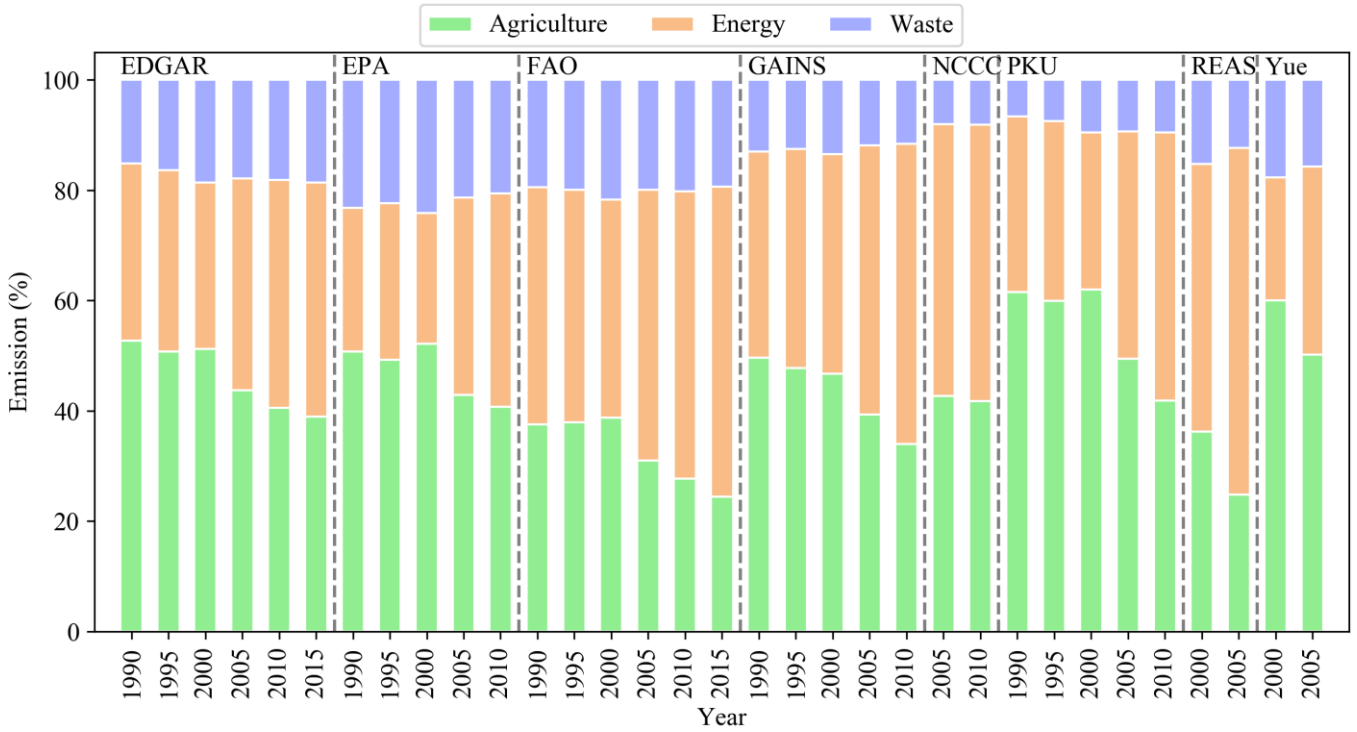

Fig. S2 Fraction changes of agriculture, energy and waste for EDGAR, EPA, FAO, GAINS, NCCC, PKU, REAS and Yue from 1990 to latest years for each inventory.

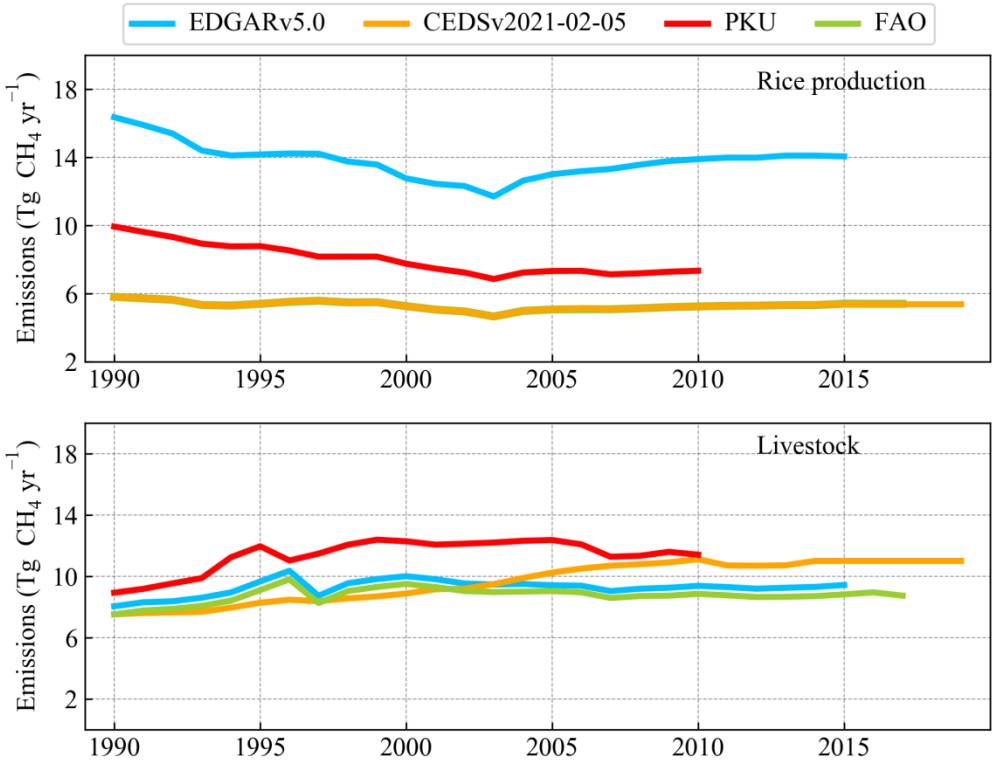

Fig. S3 CH4 Emissions of rice production and livestock for EDGAR, CEDS, PKU and FAO from 1990 to 2019.

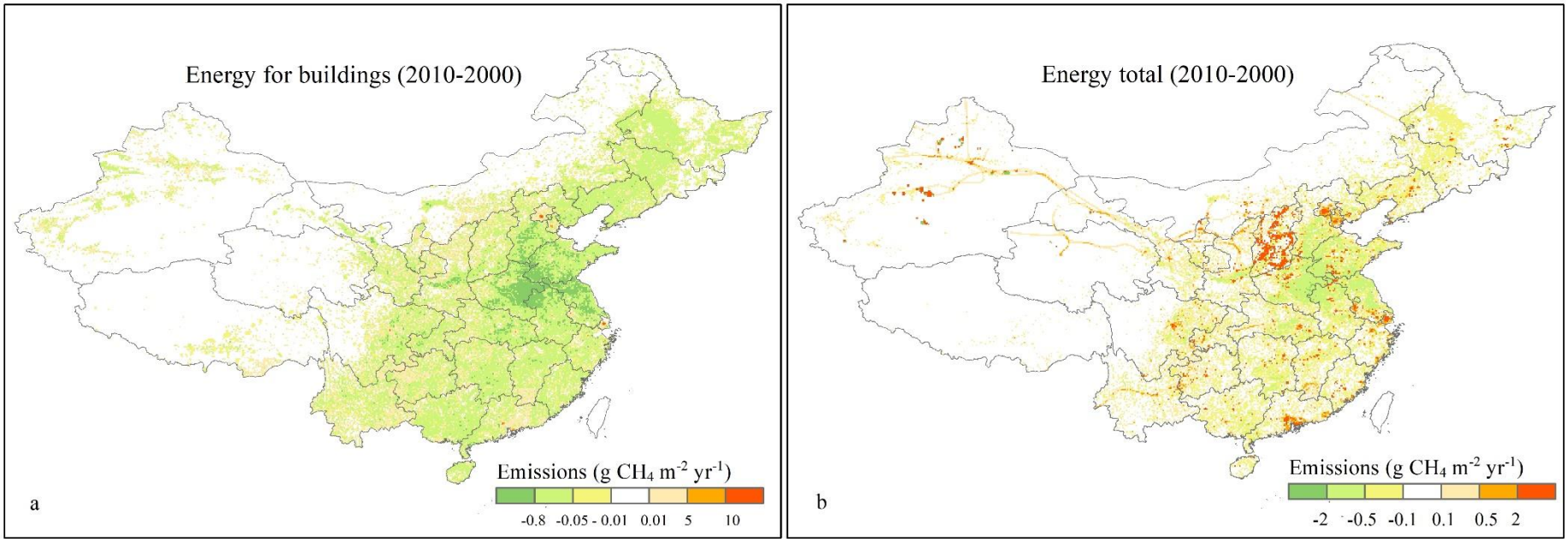

Fig. S4 Changes of CH_4 emissions of energy for buildings (a) and energy sector (b) in EDGAR from 2000 to 2010.

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