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Supplement of

A high-resolution regional emission inventory of atmospheric mercury and its comparison with multi-scale inventories: a case study of Jiangsu, China

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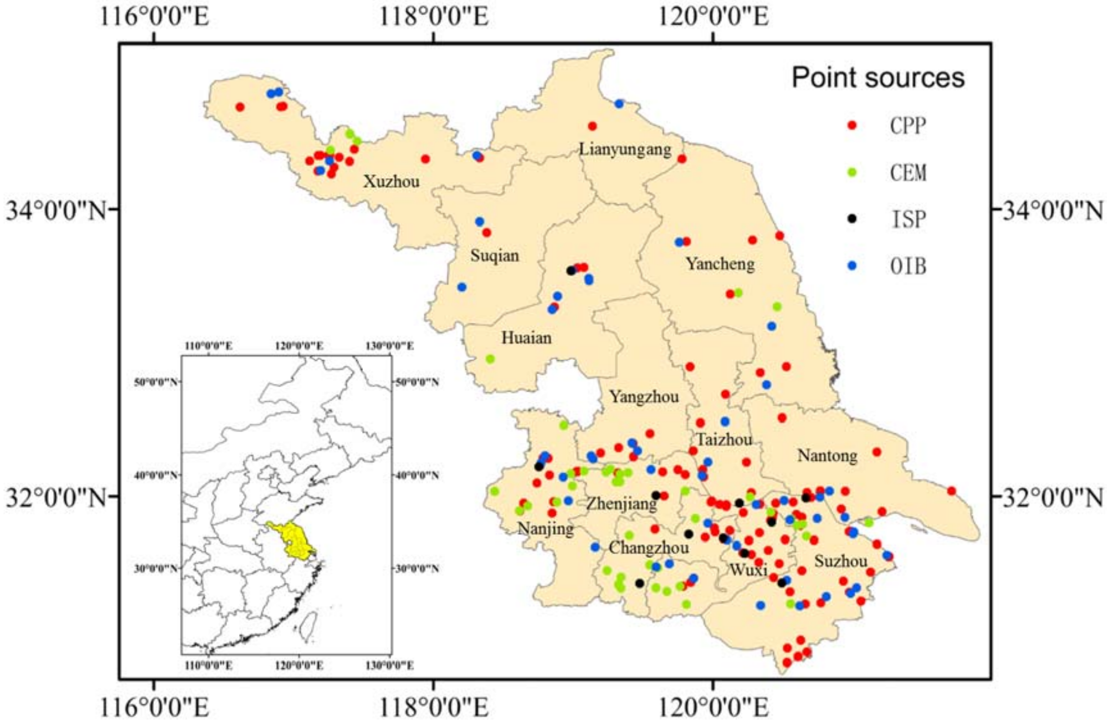
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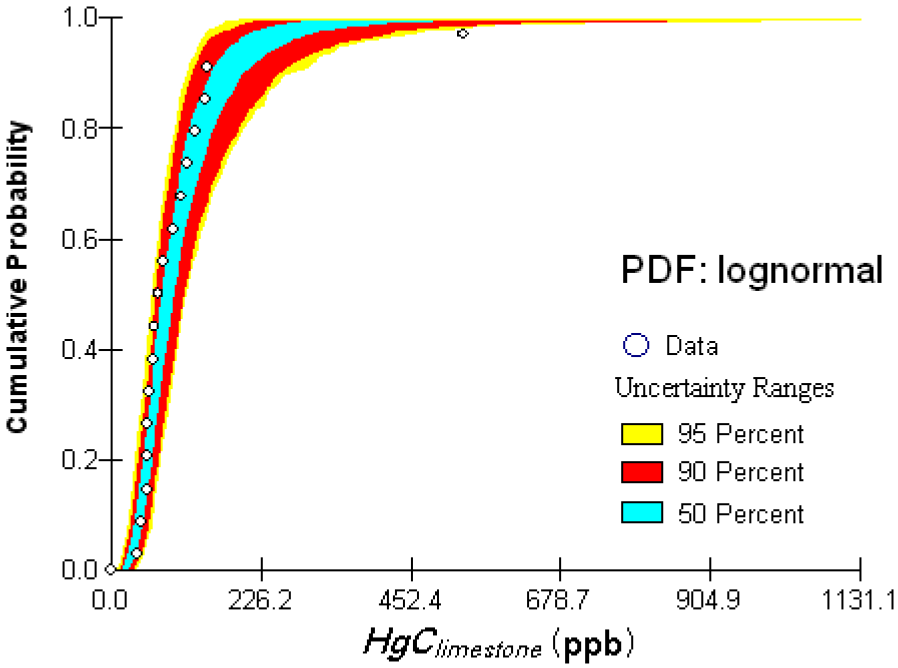
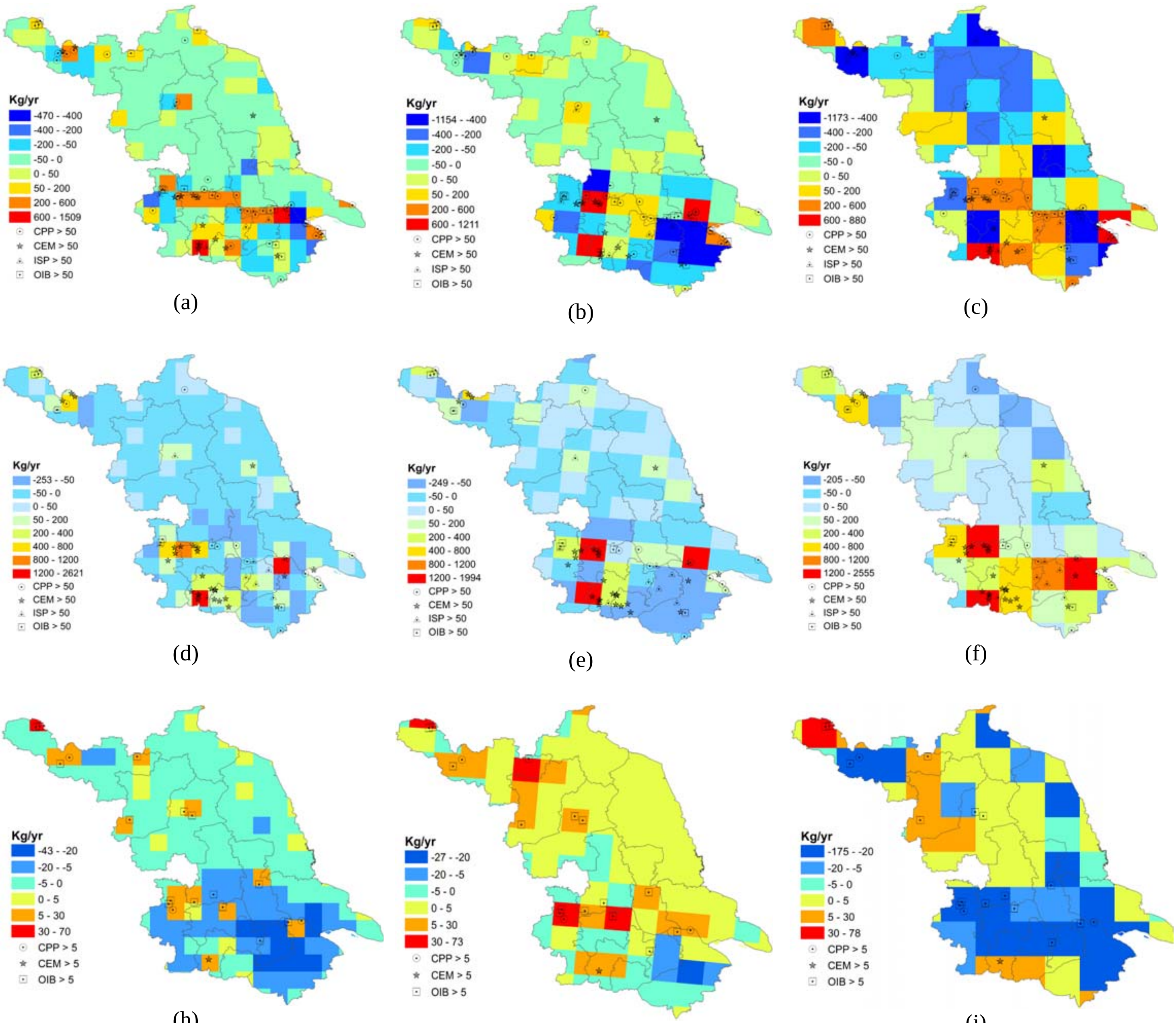
118°0'0"E
120°0'0"E
34°0'0"N
32°0'0"N
Point sources
CPP
CEM
ISP
OIB
Xuzhou
Lianyungang
Suqian
Yancheng
Huaian
Yangzhou
Taizhou
Nantong
Nanjing
Zhenjiang
Changzhou
Wuxi
Suzhou

Figure S2



1.0
0.8
0.6
0.4
0.2
0.0
Cumulative Probability
0.0
226.2
452.4
678.7
904.9
1131.1
HgC limestone (ppb)
PDF: lognormal
Data
Uncertainty Ranges
95 Percent
90 Percent
50 Percent

Figure S3



(a) (b) (c)

(d) (e) (f)

(h) (i) (j)

Table S1 Summary of calculation methods of Hg emissions for coal-fired power plants (CPP), cement production (CEM), iron & steel plants (ISP) and other industrial boilers (OIB) in multi-scale inventories.

Inventory	Sectors	Methods	Parameters
NJU	CPP/ISP /OIB	$E=\sum_{m}\sum_{t}AL_m\cdot HgC_m\cdot RR_t\cdot(1-AR_t\cdot RE_t)$	*AL*: activity levels; *HgC*: mercury content in coal *RR*: release ratios of combustor; *AR*: application ratios of control devices *RE*: removal efficacy of control devices; *EF*: emission factors *m*: province; *t*: control or combustor technology
	CEM	$E=\sum_{m}\sum_{t}AL_m\cdot EF_t\cdot AR_t$	
THU	CPP/OIB	$E=\sum_{m}AL_m\cdot HgC(X)\cdot(1-f_m\cdot w(y))\cdot\sum_{t}\cdot RR_t\cdot(1-AR_t\cdot RE_t(Z))$	*HgC(x)*: the probabilistic distribution of the Hg concentration in coal *f*: the fraction of the pretreatment of fuel or raw material *w(y)*: the probabilistic distribution of the mercury removal rate by the pretreatment $RE_t(Z)$: the probabilistic distribution of the Hg removal rate by a certain type of APCD combination
	CEM	$E=\sum_{m}AL_m\cdot HgC_{limestone}(X)\cdot\sum_{t}(1-AR_t\cdot RE_t)$	$HgC_{limestone}(x)$: the probabilistic distribution of the Hg concentration in limestone
	ISP	$E=\sum_{m}AL_m\cdot UEF$	*UEF*: uniform emission factor
BNU	CPP/OIB	$E=\sum_{m}\sum_{k}\sum_{t}AL_{m,k,t}\cdot HgC_{m,k,t}\cdot RR_{m,t}\cdot(1-RE_{m,t})$	*k* : different type of coal *DEF*: dynamic emission factors DEF_{steel} and DEF_{iron}: dynamic emission factor applied to steel and iron
	CEM	$E=\sum_{m}AL_m\cdot DEF$	
	ISP	$E=\sum_{m}AL_m\cdot DEF_{steel}+\sum_{m}AL_m\cdot DEF_{iron}$	

Table S1 (continued)

Inventory	Sectors	Methods	*Parameters*
AMAP/UNEP	CPP/ISP/ OIB/CEM	$E = \sum_t AL_t \cdot IEF \cdot (1 - AR_t \cdot RE_t)$	*IEF*: input emission factor
EDGARv4.tox2	CPP	$E = \sum_t AL_t \cdot IEF \cdot (1 - AR_t \cdot RE_t)$	EF_{sinter}, EF_{steel} and EF_{iron} : emission factor applied to sinter, steel and iron EFI_{ISP}, EF_{NMS} and EF_{other}: emission factor for coal combustion in iron and pig production, nonferrous metal smelting and other industry plants
	CEM	$E = \sum AL \cdot UEF$	
	ISP	$E = \sum AL \cdot EF_{\sin ter} + \sum AL \cdot EF_{iron} + \sum AL \cdot EF_{steel}$	
	OIB	$E = \sum AL \cdot EF_{ISP} + \sum AL \cdot EF_{NMS} + \sum AL \cdot EF_{other}$	

Table S2 Database of Hg removal efficiencies by air pollutant control device (APCD).

Control Device	Removal Efficiencies (%)	References
ESP[a]	10.78; 1.62	Wang et al. (2008b)
	13.5	Zhou et al. (2008)
	24.4; 36.16; 43.33; 15.41	Luo (2009)
	38.7	Wang et al. (2008c)
	0.4; 32.78; 23.46	L Yang et al. (2007)
	10.8; 4.7; 33.1	Xu et al. (2010)
	31.1; 31.2; 24.5	Zhu et al. (2001)
	6.0; 20.0; 4.0	Wang et al. (2008a)
	24.8	Duan et al. (2005)
	35.7	X Yang et al. (2007)
	2.17; 8.75; 23.4	Wang et al. (2011)
	36.5; 46.4; 10.3; 6.1; 23.8	Wang et al. (2010a)
	25.2	Li (2011)
	2.61; 5.83; 7.91; 15.1	C Wu et al. (2010)
	23.1; 23.8; 29.4; 17.8; 30.3; 32.2	Chen et al. (2006)
	12.8; 17.4	Li et al. (2013)
	29.4	Y Shi et al. (2013)
	46.63; 43.7; 55.9; 4.4; 37.92; 14.86; 13.49	Wang et al. (2012)
	27.9	X Shi et al. (2013)
	90	Hu and Fu (2013)
	37	Liu et al. (2014)
ESP[b]	50.6	L Yang et al. (2007)
	59.6	Gao et al. (2007)
	18.5	Wang et al. (2010a)
	55.9	Wang (2013)
ESP+FGD	67.8; 70.0; 81.36; 27.5; 35.5	Wang et al. (2010a)
	20.9; 33.9; 69.4; 70.6; 62.1; 74.2	Hu (2009)
	19.1; 2.1	Wang et al. (2008c)
	9.6	L Yang et al. (2007)
	73.5; 84.9; 54.4	Xu et al. (2010)
	62.3; 4.4; 95.9; 44.6	Wang et al. (2011)
	67.3; 78.3	Li (2011)
	62.2; 55.3; 69.5; 65.2	C Wu et al. (2010)
	68.7	Shi et al. (2013)
	25.4; 38.4	Li et al. (2013)
	77.7; 93.2; 90.8; 86.9; 83.8; 97.4	Xie and Yi (2014)
	53.2; 56.6	Wang (2013)
	65; 54	JSEMC (2013)

Table S2 (continued)

Control Device	Removal Efficiencies (%)	References
FF	75.8	L Yang et al. (2007)
	84.0; 20.7	Zhang et al. (2008)
	76.9; 23.0	Wang et al. (2008a)
	22.18	He et al. (2012)
	29	JSEMC (2013)
WET	8.7	Kilgroe et al. (2001)
	4.3	JSEMC (2013)
	26	Afonso and Senior (2001)
	8; 6.7; 10.6; 58.5	Zhang (2012)
CYC	0.1	Kilgroe et al. (2002)
	12	Huang et al. (2004)
	0	
SCR+FGD / SCR+ESP+FGD	82.2	Li (2011)
	36.5	Wang et al. (2010a)
	85	Wang et al. (2010b)
	82.2	Zhi et al. (2013)
	95	Cheng et al. (2009)
	74.1	Chen et al. (2008)
	81	JSEMC (2013)
	70.86	Zhang (2012)
	86; 80.84	Wang (2013)
	85.4	Xie and Yi (2014)
	73.55	Fu (2013)
FGD/ FGD+WET	24.3; 38	Zhong et al. (2010)
	75	Hu and Fu (2013)
	59.4	Gao et al. (2014)
	6	Q Wang et al. (2008)
FF+FGD	86	Zhang (2012)
SCR+FF+FGD	93	Zhang (2012)

[a] ESP applied with PC (pulverized combustion); [b] ESP applied with CFB (circulating fluidized bed).

Table S3 Database of mass fractions of speciated Hg by APCD.

APCDs	Mercury speciation (%) (Hg^{2+}, Hg^{p}, Hg^{0})	References
ESP	(11.4, 0.0, 88.6); (17.1, 0.0, 82.9)	Wang et al. (2008b)
	(53.5, 0.1, 46.4)	Zhou et al. (2008)
	(39.5, 0.1, 60.4)	Wang et al. (2008c)
	(11.4, 0.0, 88.6); (45.8, 0.0, 54.2); (8.1, 0.0, 91.9)	L Yang et al. (2007)
	(30.5, 0.9, 68.6); (30.2, 0.0, 69.8); (66.1, 2.4, 31.5)	Xu et al. (2010)
	(8.1, 0.0, 91.9); (44.7, 0.0, 55.3); (17.1, 0.0, 82.9)	Wang et al. (2008a)
	(74.0, 0.0, 26.0)	Duan et al. (2005)
	(7.5, 0.0, 92.5)	X Yang et al. (2007)
	(67.5, 0.1, 32.4); (49.4, 0.0, 50.6); (64.0, 0.0, 36.0); (14.3, 0.7, 85.0); (30.6, 0.0, 69.4)	Wang et al. (2010a)
	(34.0, 0.9, 65.1); (59.0, 0.2, 40.8); (79.8, 0.0, 20.2); (75.8, 0.0, 24.2); (60.0, 6.5, 33.5); (30.8, 10.4, 33.5); (45.8, 3.0, 51.2)	Wang et al. (2012)
	(73.5, 0, 26.5); (83.6, 0.1, 16.3); (27.5, 0.6, 71.9)	Zhang (2012)
	(16.2, 15.7, 68.1)	X Shi et al. (2013)
ESP+FGD	(24.8, 0.0, 75.2); (18.3, 0.0, 81.7); (8.9, 0.0, 91.1); (6.2, 0.0, 93.8); (11.5, 0.0, 88.5)	Wang et al. (2010a)
	(5.4, 0.0, 94.6); (3.9, 0, 96.1)	Wang et al. (2008b)
	(4.0, 0.0, 96.0)	L Yang et al. (2007)
	(27.7, 0.6, 71.7); (14.9, 0.0, 85.1); (53.7, 2.5, 43.8)	Xu et al. (2010)
FF	(65.4, 24.5, 10.1)	Zhang et al. (2008)
	(74.5, 8.8, 16.7); (75.6, 0.0, 24.4)	Wang et al. (2008a)
	(78, 10, 12)	L Yang et al. (2007)
	(33, 0, 64); (36, 1, 63)	Zhang (2012)
	(74, 2, 24)	He et al. (2012)
SCR+ESP / ESP+FGD	(10.7, 0.0, 89.5)	Wang et al. (2010a)
	(20.9, 0.0, 79.1); (15.6, 0.0, 84.4) (16.6, 0.0, 83.4); (17.7, 0.0, 82.3)	Zhong et al. (2010)
	(84.1, 0.0, 15.9)	Chen et al. (2008)
	(34.6, 0.4, 65.0)	Zhang (2012)
WET	(9.7, 2.9, 87.4); (16.2, 3.8, 80.0); (59.1, 0.2, 39.9); (60.4, 0.2, 39.4); (18.4, 0.5, 81.1); (30.7, 4.7, 64.6)	Zhang (2012)
FF+FGD	(78, 21, 1)	Zhang (2012)

Table S4 Emission factors and Hg speciation profiles for ISP and other selected sources in Categories 2 and 3.

Sources		EF	Unit	References	Speciation/ %		
					Hg^0	Hg^{2+}	Hg^p
ISP		0.042[a] 0.068[b]	g/t crude steel	Wang et al. (2016)	34	66	0
MSWI		0.22	g/t	Chen et al. (2013); Hu et al. (2012)	13	86	1
BFLP		0.035	t/t Hg used	AMAP/UNEP (2013)	100	0	0
PVC		0.01	t/t Hg used	THU (2009)	100	0	0
HC		1	g/corpse	UNEP (2005)	96	0	4
NMS (Cu)		0.4	g/t Cu	Zhao et al. (2015)	50	50	0
AP		0.265	g/t	THU (2006)	80	15	5
O&G	Heavy fuel	0.014	g/t	Wu et al. (2006)	50	40	10
	Oil	0.058	g/t	Wu et al. (2006)			
	Gas	0.416	g/t	Wu et al. (2006)			
BIO	Crop	16.7	ng/g	Huang et al. (2011); Zhang et al. (2013)	76	19	5
	Fuel wood	12.3	ng/g				

[a] Including mercury emissions from rotary kiln for limestone and dolomite; [b] Excluding mercury emissions from rotary kiln for limestone and dolomite

Table S5 Removal efficiencies and application ratios of various APCDs between multi-scale Hg emission inventories.

	APCDs	Bottom-up	NJU	THU	AMAP/UNEP
Removal efficiency	CYC	4.0	4.0		
	WET	17.5	13.0	23.0	
	ESP	23.5	20.3	29.0	26.0
	FGD+WET	39.7			
	CFB+ESP	46.1	42.9		
	FF	48.6	56.1	67.0	50.0
	ESP+FGD	58.8	53.8	62.0	65.0
	SCR+ESP+FGD	77.7	76.6	69.0	69.0
	FF+FGD	86.4		86.0	
	SCR+FF+FGD	93.0		93.0	
Application ratio for CPP	CYC	0.0	1.5	0.0	0.0
	WET	4.5	1.3	0.0	0.0
	ESP	3.5	13.6	10.2	7.0
	FGD+WET	2.5	0.0	0.0	0.0
	CFB+ESP	4.0	4.0	0.0	0.0
	FF	2.5	6.8	0.8	7.0
	ESP+FGD	70.0	61.6	69.8	72.0
	SCR+ESP+FGD	11.4	11.2	11.2	14.0
	FF+FGD	0.2	0.0	5.2	0.0
	SCR+FF+FGD	1.3	0.0	0.8	0.0
Application ratio for OIB	CYC	9.9	29.5	0.0	
	WET	26.9	41.9	95.0	50.0
	ESP	13.3	5.1	0.0	
	FGD+WET	4.0	0.0	0.0	0.0
	CFB+ESP	6.0	0.0	0.0	0.0
	FF	10.0	23.4	0.0	25.0
	ESP+FGD	10.8	0.0	0.0	0.0
	SCR+ESP+FGD	2.6	0.0	0.0	0.0
	FF+FGD	1.5	0.0	5.0	0.0
	No	15.0	0.0	0.0	25.0

Table S6 Uncertainties of Hg emission factors for main sources, expressed as the probability distribution functions (PDF).

Parameters		Samples	Distribution	Key characteristics for distribution functions		
				P10[a]/Min[b]	P90[a]/Max[b]	P50[a]/Most likely[b]
Mercury content in raw coal produced in given province for CPP/OIB/RCC , g/t						
Anhui		20	Lognormal	0.08	0.38	0.15
Gansu		7	Lognormal	0.04	0.17	0.07
Hebei		24	Lognormal	0.04	0.32	0.11
Heilongjiang		20	Lognormal	0.02	0.09	0.04
Henan		37	Lognormal	0.06	0.35	0.17
Inner Mongolia		46	Lognormal	0.02	0.4	0.09
Jiangsu		11	Lognormal	0.11	0.6	0.2
Shaanxi		28	Lognormal	0.02	0.53	0.08
Shandong		33	Lognormal	0.05	0.28	0.12
Shanxi		88	Lognormal	0.03	0.36	0.09
Release rates of boilers for CPP, %						
PC		32	Triangular	89	100	99
Grate		2	Triangular	92	100	96
CFB		3	Triangular	93	100	98
Release rates of boilers for OIB/HB/FOS, %						
Grate		3	Triangular	51	91	76
CFB		1	Triangular	51	100	91
Hg removal efficiency by APCDs for CPP and CEM, %						
FF		7	Weibull	21	84	49
ESP		54	Normal	21	27	24
WET		6	Weibull	11	26	18
FGD+ESP		40	Weibull	44	70	59
CYC		3	Uniform	0	14	-
SCR		12	Weibull	70	84	78
CFB+ESP		4	Weibull	33	60	46
DPT+DR		3	Uniform	2	10	-
SKT/RKT+ESP		2	Triangular	10	80	22
SKT/RKT+FF		2	Triangular	21	84	80
Hg content in raw materials for CEM, ppb						
limestone			Lognormal	81	123	101
other raw materials		1	Normal	51	65	58
Iron & Steel plants						
$EF_{\text{with raw material production}}$		1	Uniform	0.04	0.1	-
$EF_{\text{without raw material production}}$		1	Uniform	0.03	0.07	-
Biofuel use/biomass open burning						
Firewood		26	Uniform	0	50	-
Crops		9	Uniform	0	106	-
Waste incineration						
Municipal		29	Weibull	0.21	0.32	0.27
Rural	Release rates	1	Normal	0.37	0.63	0.5
	Hg content	31	Weibull	0.12	1.58	0.6

[a] P10 values mean that there is a probability of 10% that the actual result would be equal to or below the P10 values; P50 mean that there is a probability of 50% that the actual result would be equal to or below the P50 values; and P90 mean that there is a probability of 90% that the actual result would be equal to or below the P90 values.

[b] These values are for the minimum, the most likely, and the maximum values for the triangular distribution function instead of P10, P50, and P90 values, or for the minimum and maximum values for the uniform distribution function instead of P10 and P90 values.

Table S7 Uncertainties of mass fractions of Hg speciation for main source categories, expressed as the probability distribution functions (PDF).

Parameters		Samples	Distribution	Key characteristics for distribution functions / %		
				P10/Min	P90a/Max	P50/Most likely
FF	Hg^0	7	Triangular	10	64	31
	Hg^p	7	Triangular	0	25	7
ESP	Hg^{2+}	31	Weibull	30	52	41
	Hg^p	31	Triangular	0	15	1
FGD+ESP	Hg^{2+}	11	Triangular	4	54	16
	Hg^p	11	Triangular	0	1	0.3
WET	Hg^0	6	Uniform	10	60	33
	Hg^p	6	Uniform	0.2	5	2
NOC [a]	Hg^0	37	Triangular	0	89	48
	Hg^p	37	Gamma	0.02	50	6
SCR	Hg^{2+}	7	Triangular	11	84	29
	Hg^p	7	Triangular	0	0.5	0.1
DPT+DR	Hg^0	3	Triangular	9	39	23.8
	Hg^p	3	Triangular	0	1.6	0.5
ISP	Hg^0	2	Triangular	25	78	34
BIO	Hg^0	25	Weibull	57.3	94.2	76.9
	Hg^{2+}	25	Triangular	0	21.7	5
SWI	Hg^0	10	Gamma	1.1	33.8	6.2
	Hg^p	10	Gamma	0.1	2.6	0.5

[a] No control device for coal combustion

Table S8 The parameters contributing most to emission uncertainties by sector for 2010. The percentages indicate the contributions of the parameters to the variance of corresponding emission estimates.

	HgT	Hg^0	Hg^{2+}	Hg^p
CPP	$HgC_{Shaanxi}$ 26%	$HgC_{Shaanxi}$ 23%	$F_{ESP+FGD\_Hg}{}^{2+}$ 33%	$F_{ESP\_Hg}{}^{p}$ 35%
	$RE_{ESP+FGD}$ 20%	$RE_{ESP+FGD}$ 21%	$HgC_{Shaanxi}$ 19%	$HgC_{Shaanxi}$ 15%
	$HgC_{Inner\ Mongolia}$ 18%	$HgC_{Inner\ Mongolia}$ 16%	$HgC_{Inner\ Mongolia}$ 12%	$HgC_{Inner\ Mongolia}$ 10%
CEM	$HgC_{limestone}$ 84%	$F_{DPT+DR\_Hg}{}^{0}$ 66%	$HgC_{limestone}$ 65%	$F_{DPT+DR\_Hg}{}^{p}$ 90%
	Al_i 7%	$HgC_{limestone}$ 27%	$F_{DPT+DR\_Hg}{}^{0}$ 21%	$HgC_{limestone}$ 6%
	RE_{DPT+DR} 3%	Al_i 3%	Al_i 5%	/
ISP	$EF_{limestone\ and\ dolomite}$ 60%	$F_{Hg}{}^{0}$ 66%	$F_{Hg}{}^{0}$ 59%	
	Al_i 24%	$EF_{limestone\ and\ dolomite}$ 24%	$EF_{limestone\ and\ dolomite}$ 28%	/
	/	Al_i 7%	Al_i 9%	
OIB	$HgC_{Shaanxi}$ 15%	$HgC_{Shaanxi}$ 10%	$HgC_{Shaanxi}$ 12%	$F_{NOC\_Hg}{}^{p}$ 30%
	$HgC_{Inner\ Mongolia}$ 11%	$HgC_{Inner\ Mongolia}$ 13%	$HgC_{Inner\ Mongolia}$ 8%	$HgC_{Shaanxi}$ 5%
	RR_{Grate} 5%	RR_{Grate} 3%	RR_{Grate} 3%	RR_{Grate} 2%
Rest	EF_{MSWI} 37%	EF_{crop} 46%	EF_{MSWI} 70%	EF_{crop} 55%
	EF_{crop} 31%	EF_{oil} 11%	EF_{oil} 9%	$F_{crop\_Hg}{}^{p}$ 20%
	EF_{oil} 16%	RR_{IUS} 7%	F_{oil_Hg2+} 6%	EF_{oil} 8%
Total	$HgC_{Shaanxi}$ 12%	$HgC_{Shaanxi}$ 12%	$HgC_{Shaanxi}$ 8%	$F_{NOC\_Hg}{}^{p}$ 18%
	$HgC_{Inner\ Mongolia}$ 8%	$HgC_{Inner\ Mongolia}$ 8%	$HgC_{limestone}$ 8%	EF_{crop} 9%
	$HgC_{jiangsu}$ 7%	$HgC_{jiangsu}$ 7%	$HgC_{Inner\ Mongolia}$ 5%	$F_{crop\_Hg}{}^{p}$ 5%
	$RE_{ESP+FGD}$ 4%	$RE_{ESP+FGD}$ 6%	$HgC_{jiangsu}$ 4%	$HgC_{Shaanxi}$ 4%

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