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*Supplement of*

## **An updated emission inventory of vehicular VOCs and IVOCs in China**

**Huan Liu et al.**

*Correspondence to:* Huan Liu (liu\_env@tsinghua.edu.cn)

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10 **Table S1. Previous studies on emission inventory of VOCs from vehicles in China.**

Study	Target year	Target region	Target emission sources	Target pollutants	China's Transport source NMVOCs emission amount in the target year (Gg/year)
<i>Bo et al. (2008)</i>	1980	China	Anthropogenic sources	NMVOCs	217
<i>Bo et al. (2008)</i>	1985	China	Anthropogenic sources	NMVOCs	435
<i>Bo et al. (2008)</i>	1990	China	Anthropogenic sources	NMVOCs	807
<i>Klimont et al. (2001)</i>	1990	China	Anthropogenic sources	NMVOCs	2317
<i>Tonooka et al. (2001)</i>	1994-1995	East Asia	Anthropogenic sources	NMVOCs, CO	1477
<i>Klimont et al. (2001)</i>	1995	China	Anthropogenic sources	NMVOCs	3567
<i>Li et al. (2003)</i>	1995	China	On-road transportation	THC, NMVOCs, CH <sub>4</sub> , CO, NO <sub>x</sub> , CO <sub>2</sub> , SO <sub>2</sub> , Pb, PM <sub>10</sub> , N <sub>2</sub> O	3264
<i>Klimont et al. (2001)</i>	2000	China	Anthropogenic sources	NMVOCs	5071
<i>Streets et al. (2003)</i>	2000	Asia	Anthropogenic sources	SO <sub>2</sub> , NO <sub>x</sub> , CO <sub>2</sub> , CO, CH <sub>4</sub> , NMVOCs, BC, OC, NH <sub>3</sub>	394.2
<i>Liu et al. (2008)</i>	2000	China	Anthropogenic sources	VOCs	2710
<i>Bo et al. (2008)</i>	2000	China	Anthropogenic sources	NMVOCs	3081
<i>Wei et al. (2008)</i>	2005	China	Anthropogenic sources	NMVOCs	4700
<i>Cai et al. (2007)</i>	2005	China	On-road transportation	CH <sub>4</sub> , CO, CO <sub>2</sub> , NMVOCs, NO <sub>x</sub> , PM <sub>10</sub> , SO <sub>2</sub>	5911
<i>Bo et al. (2008)</i>	2005	China	Anthropogenic sources	NMVOCs	5490
<i>Cai et al. (2009)</i>	2005	China	On-road transportation	NMVOCs	5959

<i>Zhang et al. (2009)</i>	2006	Asia	Anthropogenic sources	SO <sub>2</sub> , NO <sub>x</sub> , CO, NMVOCs, PM <sub>10</sub> , PM <sub>2.5</sub> , BC, OC	6630
<i>Li et al. (2014)</i>	2006	Asia	Anthropogenic sources	NMVOCs	5475
<i>Cao et al. (2011)</i>	2007	China	Anthropogenic sources	PM <sub>2.5</sub> , BC, OC, SO <sub>2</sub> , NO <sub>x</sub> , CO, NH <sub>3</sub> , VOCs	4099
<i>Klimont et al. (2001)</i>	2010	China	Anthropogenic sources	NMVOCs	4495
<i>Wei et al. (2011)</i>	2010	China	Anthropogenic sources	NMVOCs	5630
<i>Wei et al. (2011)</i>	2015	China	Anthropogenic sources	NMVOCs	3570
<i>Klimont et al. (2001)</i>	2020	China	Anthropogenic sources	NMVOCs	3559
<i>Wei et al. (2011)</i>	2020	China	Anthropogenic sources	NMVOCs	2960

12 **Table S2. Mapping from vehicles in US to China certification level (Gasoline).**

Vehicle name	Model year	Vehicle class*	Engine size (L)	Emission Certification Standard	Test cycle	Mapping to China Emission Certification Standard	Total IVOC Emission factors (mg/kg-fuel)
PreLEV-1	1987	PC	4	Tier I	Cold UC	China1	259.50
PreLEV-2	1988	PC	2	Tier I	Cold UC	China1	1693.51
PreLEV-2	1988	PC	2	Tier I	Cold UC	China1	901.95
PreLEV-4	1989	PC	1	Tier I	Cold UC	China1	252.92
PreLEV-3	1990	M3	5	Tier I	Cold UC	China1	104.55
PreLEV-3	1990	PC	5	Tier I	Hot UC	China1	108.88
PreLEV-5	1991	PC	4	LEV	Cold UC	China1	63.08
PreLEV-8	1991	PC	4	Tier I	Cold UC	China1	149.69
PreLEV-9	1991	PC	4	Tier I	Cold UC	China1	150.96
PreLEV-10	1992	PC	3	Tier I	Cold UC	China1	167.87
PreLEV-11	1992	PC	4	Tier I	Cold UC	China1	184.64
PreLEV-14	1993	PC	5	Tier I	Cold UC	China1	153.47
PreLEV-15	1993	T2	4	Tier I	Cold UC	China1	627.96
LEV1-8	1994	PC	2	LEV1; Tier I	Cold UC	China2	237.56
LEV1-1	1996	PC	2.7	Tier I	Cold UC	China2	61.77
LEV1-1	1996	PC	2.7	Tier I	Cold UC	China2	50.33
LEV1-2	1997	PC	3	LEV	Cold UC	China2	26.06
LEV1-2	1997	PC	3	LEV	Cold UC	China2	20.87
LEV1-2	1997	PC	3	LEV	Hot UC	China2	32.55
LEV1-16	1998	PC	1.8	LEV1, TLEV	Cold UC	China3	128.69
LEV1-3	1998	PC	3	LEV	Cold UC	China2	98.38
LEV1-3	1998	PC	3	LEV	Arterial	China2	4.18
LEV1-3	1998	PC	3	LEV	Freeway	China2	27.06
LEV1-17	1999	T2	4	LEV1, NLEV	Cold UC	China3	25.39
LEV1-4	1999	PC	2	TLEV	Cold UC	China2	9.79
LEV1-19	2000	PC	3.5	LEV1	Cold UC	China3	46.71
LEV1-19	2000	PC	3.5	LEV1	Cold UC	China3	54.82
LEV1-21	2001	PC	2.2	LEV	Cold UC	China4	26.37
LEV1-24	2002	PC	5.7	LEV	Cold UC	China4	30.69
LEV1-24	2002	PC	5.7	LEV	Cold UC	China4	38.23
LEV1-25	2003	PC	3	LEV1; Tier I	Cold UC	China4	86.34
LEV1-26	2003	PC	1.8	LEV1, ULEV	Cold UC	China4	41.30

LEV1-6	2003	PC	3.5	LEV1, NLEV	Cold UC	China4	472.35
LEV2-8	2004	PC	2	LEV2; Tier II, Bin 8	Cold UC	Chian4	59.29
LEV2-10	2005	T2	3	LEV2; Tier II, Bin 5	Cold UC	China4	37.45
LEV2-11	2005	PC	2	LEV2, ULEV; Tier II, Bin 5	Cold UC	China4	101.52
LEV2-13	2008	PC	2	LEV2, ULEV; Tier II, Bin 5	Cold UC	China5	22.39
LEV2-15	2008	PC	3	LEV2	Cold UC	China5	22.86
LEV2-16	2008	PC	4	LEV2; Tier II, Bin 5	Cold UC	China5	7.10
LEV2-2	2008	T2	4	LEV2	Cold UC	China5	17.08
LEV2-3	2008	PC	4	LEV2	Hot UC	China5	21.82
LEV2-3	2008	PC	4	LEV2	Cold UC	China5	25.01
LEV2-18	2009	T2	6	Tier II	Cold UC	China5	28.47
LEV2-19	2009	PC	2	LEV2, ULEV; Tier II, Bin 5	Cold UC	China5	11.81
LEV2-20	2009	PC	2	LEV2, ULEV	Cold UC	China5	15.29
LEV2-4	2010	T2	4	ULEV; Tier II	Cold UC	China5	6.88
LEV2-4	2010	T2	4	ULEV; Tier II	Cold UC	China5	47.15
LEV2-23	2011	PC	n/a	LEV2, ULEV	Cold UC	China5	18.03
LEV2-5	2011	PC	2	ULEV	Cold UC	China5	28.46
LEV2-5	2011	PC	2	ULEV	Cold UC	China5	35.36
LEV2-5	2011	PC	2	ULEV	Cold UC	China5	17.13
LEV2-6	2011	PC	4	LEV2, ULEV	Cold UC	China5	21.15
LEV2-6	2011	PC	4	LEV2, ULEV	Arterial	China5	16.14
LEV2-6	2011	PC	4	LEV2, ULEV	Freeway	China5	27.15
LEV2-24	2012	M3	4	ULEV	Cold UC	China5	19.54
LEV2-7	2012	PC	2	PZEV	Cold UC	China5	40.37
LEV1-9	N/A	N/A	N/A	N/A	Cold UC	China2	385.42

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15 **Table S3. Mapping from vehicles in US to China certification level (Diesel).**

Vehicle ID	Model year	Mileage	Engine displacement (L)	Average fuel economy(MPG)	After-treatment	Mapping to China Emission Certification Standard	Total IVOC emission factors (mg/kg-fuel)
1	2010	11000	14.9	4.5	DPF+SCR+DOC	China6	104.85
1	2010	11000	14.9	4.5	DPF+SCR+DOC	China6	16.67
2	2007	22000	12.8	4.9	DPF+DOC	China5	1066.94
2	2007	22000	12.8	4.9	DPF+DOC	China5	18.72
2	2007	22000	12.8	4.9	DPF+DOC	China5	25.11
2	2007	22000	12.8	4.9	DPF+DOC	China5	37.14
2	2007	22000	12.8	4.9	DPF+DOC	China5	30.54
2	2007	22000	12.8	4.9	DPF+DOC	China5	22.77
3	2006	94000	10.8	4.3	NONE	China4	3448.35
3	2006	94000	10.8	4.3	NONE	China4	626.95
3	2006	94000	10.8	4.3	NONE	China4	565.07
3	2006	94000	10.8	4.3	NONE	China4	703.41
3	2006	94000	10.8	4.3	NONE	China4	3072.29
3	2006	94000	10.8	4.3	NONE	China4	3858.87
3	2006	94000	10.8	4.3	NONE	China4	592.03
3	2006	94000	10.8	4.3	NONE	China4	687.64
3	2006	94000	10.8	4.3	NONE	China4	685.02
3	2006	94000	10.8	4.3	NONE	China4	5353.78
3	2006	94000	10.8	4.3	NONE	China4	898.63
3	2006	94000	10.8	4.3	NONE	China4	796.78
4	2005	66000	6.6	11.8	DOC*	China4	767.83
5	2001	159000	5.9	13.7	NONE	China3	631.35

17 **Table S4. VOCs tailpipe emission factors used in this study (g/km).**

<b>Passenger vehicles</b>						
	China 0	China 1	China 2	China 3	China 4	China 5
LDGTAs	3.840	1.368	0.963	0.454	0.277	0.257
LDDTAs	0.785	0.071	0.046	0.024	0.016	0.016
LDATAs	3.788	0.433	0.398	0.115	0.066	0.293
LDGPVs	2.685	0.663	0.314	0.191	0.075	0.056
LDDPVs	0.785	0.071	0.046	0.024	0.016	0.016
LDAPVs	2.236	0.236	0.164	0.094	0.062	0.091
MDGBUs	5.144	5.255	1.980	0.869	0.418	0.418
MDDBUs	2.668	0.576	0.351	0.283	0.107	0.054
MDABUs	3.840	3.200	2.860	1.720	1.192	1.192
MDGPVs	3.695	2.567	1.443	0.373	0.107	0.107
MDDPVs	1.493	1.425	0.425	0.364	0.383	0.383
MDAPVs	1.920	1.600	1.430	0.860	0.596	0.596
HDGBUs	5.144	5.255	1.980	0.869	0.418	0.418
HDDBUs	2.668	0.576	0.351	0.283	0.107	0.054
HDABUs	3.840	3.200	2.860	1.720	1.192	1.192
HDGPVs	5.144	5.255	1.980	0.869	0.418	0.418
HDDPVs	2.668	0.576	0.351	0.283	0.107	0.054
HDAPVs	3.840	3.200	2.860	1.720	1.192	1.192
<b>Trucks</b>						
	China 0	China 1	China 2	China 3	China 4/ 5	
Urban road	LDGTs	5.391	3.593	2.389	0.637	0.176
	LDDTs	2.267	2.205	1.411	0.384	0.194
	MDGTs	7.441	7.326	3.268	1.482	0.619
	MDDTs	4.863	1.742	0.455	0.219	0.111
	HDGTs	7.295	7.306	3.249	1.464	0.600
	HDDTs	4.413	0.970	0.562	0.276	0.139
Provincial road	LDGTs	4.040	2.693	1.841	0.530	0.147
	LDDTs	1.699	1.653	1.087	0.320	0.162
	MDGTs	5.577	5.490	2.449	1.111	0.464
	MDDTs	3.645	1.306	0.341	0.164	0.083
	HDGTs	5.467	5.475	2.435	1.097	0.450
	HDDTs	3.308	0.727	0.421	0.207	0.105
National road	LDGTs	4.376	2.916	1.924	0.549	0.152
	LDDTs	1.840	1.790	1.136	0.331	0.167
	MDGTs	6.040	5.946	2.652	1.203	0.503
	MDDTs	3.947	1.414	0.369	0.178	0.090
	HDGTs	5.921	5.930	2.637	1.188	0.487
	HDDTs	3.582	0.787	0.456	0.224	0.113
Freeway	LDGTs	4.119	2.745	1.837	0.536	0.148

	LDDTs	1.732	1.685	1.085	0.323	0.163
	MDGTs	5.685	5.597	2.497	1.132	0.473
	MDDTs	3.716	1.331	0.348	0.168	0.085
	HDGTs	5.574	5.582	2.483	1.118	0.458
	HDDTs	3.372	0.741	0.429	0.211	0.107
	LDGTs	7.010	4.673	3.059	0.798	0.221
	LDDTs	2.948	2.868	1.806	0.482	0.243
County road	MDGTs	9.677	9.527	4.250	1.927	0.805
	MDDTs	6.324	2.266	0.592	0.285	0.145
	HDGTs	9.487	9.501	4.226	1.903	0.780
	HDDTs	5.740	1.261	0.731	0.358	0.181
<b>GMs</b>						
	GMs				1.269	

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20 **Table S5. IVOCs tailpipe emission factors used in this study (g/km).**

<b>Passenger vehicles</b>					
	China 0/1	China 2	China 3	China 4	China 5
LDDTAs/LDGTAs/LDGPVs/LDDPVs	<b>0.09287<sup>1</sup></b>	<b>0.00977</b>	<b>0.00809</b>	<b>0.00413</b>	<b>0.00151</b>
MDGBUs/MDDDBUs/MDGPVs/MDDPVs	<b>0.01837</b>	<b>0.00424</b>	<b>0.00532</b>	<b>0.00532</b>	<b>0.00221</b>
HDGBUs/HDDDBUs/HDGPVs/HDDPVs	<b>0.01671</b>	<b>0.00447</b>	<b>0.00447</b>	<b>0.02553</b>	<b>0.00231</b>
<b>Trucks</b>					
	China 0/1	China 2	China 3	China 4	China 5
LDGTs	<b>0.07200</b>	<b>0.00266</b>	<b>0.00266</b>	<b>0.00333</b>	<b>0.00272</b>
LDDTs	0.06072 <sup>2</sup>	0.06072	0.06072	0.08574	0.08574
MDGTs	0.10800	0.00399	0.00399	0.00500	0.00409
MDDTs	0.09108	0.09108	<b>0.09108</b>	<b>0.12861</b>	0.01122
HDGTs	0.10800	0.00399	0.00399	0.00500	0.00409
HDDTs	0.34478	0.34478	0.34478	<b>0.34478</b>	<b>0.01122</b>

21 <sup>1</sup> The bold fonts mean that data is from measurements in literature. It is equal to the median of measurements for all  
 22 samples in this vehicle category.

23 <sup>2</sup> The non-bold fonts mean that no measurement data is available. The emission factor is derived based on the  
 24 following assumptions: EF(HD)=EF(MD)=1.5\*EF(LD) and EF (control level) = EF (control level ± n, where  
 25 measurement data is available).

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28 **Table S6. Evaporation emission factors used in this study.**

		Parking duration	Unite	Emission factors
vehicles	Diurnal	<24 hour	g/hour	0.094 <sup>1</sup>
		24-48 hour	g/hour	0.247 <sup>1</sup>
		>48 hour	g/hour	0.339 <sup>1</sup>
	Hot soak		g/hour	0.083 <sup>1</sup>
	Refueling (without control)		g/L	0.848 <sup>1</sup>
	Running loss		g/hour	11.6 <sup>2</sup>
motorcycle			g/km	0.57 <sup>3</sup>

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31 **Table S7. Characteristics of probability distribution functions for selected key**  
 32 **model parameters and input variables included in the uncertainty analysis.**

Parameter or variable			Distribution	Standard division	The 95% confidence interval		
					2.5% percentile	50 % percentile	97.5% percentile
Evaporative emission factors	Diurnal emissions (g/hour)	1-24hour	Log-Normal	0.065	0.023	0.077	0.264
		24-48hour	Log-Normal	0.100	0.107	0.229	0.493
		>48hour	Log-Normal	0.085	0.204	0.331	0.536
	Hot Soak (g/hour)		Log-Normal	0.014	0.059	0.082	0.114
	Base Refuelling (g/L)		Log-Normal	0.077	0.707	0.843	1.009
	Running loss (g/hour)		Log-Normal	4.689	5.072	10.712	22.938
	GMs (g/Km)		Log-Normal	0.550	0.086	0.415	1.945
Parking duration per day in Beijing (hour)			Extreme Value	1.1365	19.4652	22.3486	23.8540
Parking duration per day in other provinces (hour)			Extreme Value	0.9919	19.7238	22.2438	23.5538
Percentage of parking events in Beijing	0-1hour		Log-Normal	0.100	0.320	0.475	0.712
	1-24hour		Log-Normal	0.099	0.306	0.460	0.688
	24-48hour		Log-Normal	0.006	0.018	0.027	0.041
	48-72hour		Log-Normal	0.002	0.004	0.007	0.012
	72-119.5hour		Log-Normal	0.002	0.002	0.005	0.010
	>119.5hour		Log-Normal	0.000	0.004	0.004	0.005
Percentage of parking events in other provinces	0-1hour		Log-Normal	0.124	0.352	0.539	0.834
	1-24hour		Log-Normal	0.079	0.290	0.420	0.605
	24-48hour		Log-Normal	0.002	0.007	0.010	0.015
	48-72hour		Log-Normal	0.000	0.002	0.003	0.004
	72-119.5hour		Log-Normal	0.002	0.000	0.002	0.007
	>119.5hour		Log-Normal	0.004	0.000	0.001	0.010
Percentage of parking duration in Beijing	0-1hour		Log-Normal	0.006	0.020	0.029	0.043
	1-24hour		Log-Normal	0.099	0.316	0.471	0.703
	24-48hour		Log-Normal	0.040	0.101	0.162	0.260
	48-72hour		Log-Normal	0.014	0.048	0.071	0.103
	72-119.5hour		Log-Normal	0.020	0.050	0.080	0.127
	>119.5hour		Log-Normal	0.040	0.103	0.163	0.255
Percentage of parking duration in	0-1hour		Log-Normal	0.020	0.024	0.049	0.101
	1-24hour		Log-Normal	0.121	0.433	0.628	0.902
	24-48hour		Log-Normal	0.184	0.004	0.043	0.468
	48-72hour		Log-Normal	0.010	0.030	0.046	0.069

other provinces	72-119.5hour	Log-Normal	0.020	0.022	0.047	0.098	
	>119.5hour	Log-Normal	0.020	0.084	0.117	0.161	
Tailpipe Emission factors of passenger vehicles (g/Km)	GMs		Log-Normal	0.56	0.52	1.16	2.64
	LDGTAs	China0	Log-Normal	1.694	1.550	3.519	8.045
		China1	Log-Normal	0.599	0.558	1.255	2.839
		China2	Log-Normal	0.418	0.392	0.891	1.968
		China3	Log-Normal	0.200	0.184	0.416	0.957
		China4	Log-Normal	0.121	0.112	0.254	0.582
		China5	Log-Normal	0.114	0.104	0.236	0.543
	LDDTAs	China0	Log-Normal	0.337	0.311	0.726	1.608
		China1	Log-Normal	0.031	0.028	0.065	0.150
		China2	Log-Normal	0.020	0.019	0.042	0.096
		China3	Log-Normal	0.010	0.010	0.022	0.050
		China4	Log-Normal	0.007	0.006	0.015	0.033
		China5	Log-Normal	0.007	0.006	0.015	0.033
	LDDATAs	China0	Log-Normal	1.649	1.516	3.471	7.828
		China1	Log-Normal	0.187	0.174	0.396	0.884
		China2	Log-Normal	0.176	0.159	0.367	0.829
		China3	Log-Normal	0.050	0.046	0.105	0.241
		China4	Log-Normal	0.029	0.027	0.060	0.139
		China5	Log-Normal	0.127	0.118	0.270	0.608
	LDGPVs	China0	Log-Normal	1.181	1.105	2.473	5.687
		China1	Log-Normal	0.293	0.269	0.608	1.385
		China2	Log-Normal	0.140	0.127	0.287	0.654
		China3	Log-Normal	0.083	0.077	0.174	0.395
		China4	Log-Normal	0.033	0.031	0.069	0.158
		China5	Log-Normal	0.025	0.023	0.052	0.115
	LDDPVs	China0	Log-Normal	0.337	0.311	0.726	1.608
		China1	Log-Normal	0.031	0.028	0.065	0.150
		China2	Log-Normal	0.020	0.019	0.042	0.096
		China3	Log-Normal	0.010	0.010	0.022	0.050
		China4	Log-Normal	0.007	0.006	0.015	0.033
China5		Log-Normal	0.007	0.006	0.015	0.033	
LDAPVs	China0	Log-Normal	0.977	0.900	2.071	4.581	
	China1	Log-Normal	0.104	0.095	0.217	0.486	
	China2	Log-Normal	0.073	0.067	0.151	0.347	
	China3	Log-Normal	0.065	0.023	0.077	0.264	
	China4	Log-Normal	0.027	0.025	0.056	0.127	
	China5	Log-Normal	0.039	0.037	0.084	0.186	

	MDGBUs	China0	Log-Normal	2.223	2.100	4.741	10.559
		China1	Log-Normal	2.306	2.142	4.859	10.957
		China2	Log-Normal	0.852	0.788	1.805	4.030
		China3	Log-Normal	0.383	0.346	0.791	1.838
		China4	Log-Normal	0.184	0.167	0.380	0.872
		China5	Log-Normal	0.184	0.167	0.380	0.872
	MDDBUs	China0	Log-Normal	1.184	1.068	2.424	5.614
		China1	Log-Normal	0.254	0.234	0.532	1.211
		China2	Log-Normal	0.153	0.141	0.323	0.728
		China3	Log-Normal	0.122	0.114	0.260	0.583
		China4	Log-Normal	0.047	0.042	0.098	0.220
		China5	Log-Normal	0.024	0.021	0.050	0.112
	MDABUs	China0	Log-Normal	1.694	1.550	3.519	8.045
		China1	Log-Normal	1.415	1.299	2.945	6.765
		China2	Log-Normal	1.256	1.146	2.609	5.943
		China3	Log-Normal	0.745	0.697	1.555	3.567
		China4	Log-Normal	0.517	0.484	1.100	2.460
		China5	Log-Normal	0.517	0.484	1.100	2.460
	MDGPVs	China0	Log-Normal	1.623	1.482	3.364	7.725
		China1	Log-Normal	1.123	1.043	2.351	5.301
		China2	Log-Normal	0.628	0.587	1.324	2.993
		China3	Log-Normal	0.165	0.150	0.338	0.779
		China4	Log-Normal	0.047	0.042	0.098	0.220
		China5	Log-Normal	0.047	0.042	0.098	0.220
	MDDPVs	China0	Log-Normal	0.663	0.602	1.373	3.165
		China1	Log-Normal	0.612	0.576	1.301	2.933
		China2	Log-Normal	0.185	0.172	0.391	0.873
		China3	Log-Normal	0.160	0.146	0.335	0.764
		China4	Log-Normal	0.166	0.155	0.348	0.797
		China5	Log-Normal	0.166	0.155	0.348	0.797
MDAPVs	China0	Log-Normal	0.834	0.763	1.753	4.002	
	China1	Log-Normal	0.704	0.650	1.479	3.335	
	China2	Log-Normal	0.628	0.571	1.305	2.985	
	China3	Log-Normal	0.376	0.347	0.780	1.797	
	China4	Log-Normal	0.259	0.246	0.550	1.245	
	China5	Log-Normal	0.259	0.246	0.550	1.245	
MDGBUs	China0	Log-Normal	2.223	2.100	4.741	10.559	
	China1	Log-Normal	2.306	2.142	4.859	10.957	
	China2	Log-Normal	0.852	0.788	1.805	4.030	

		China3	Log-Normal	0.383	0.346	0.791	1.838
		China4	Log-Normal	0.184	0.167	0.380	0.872
		China5	Log-Normal	0.184	0.167	0.380	0.872
	HDDBUs	China0	Log-Normal	1.184	1.068	2.424	5.614
		China1	Log-Normal	0.254	0.234	0.532	1.211
		China2	Log-Normal	0.153	0.141	0.323	0.728
		China3	Log-Normal	0.122	0.114	0.260	0.583
		China4	Log-Normal	0.047	0.042	0.098	0.220
		China5	Log-Normal	0.024	0.021	0.050	0.112
	HDABUs	China0	Log-Normal	1.694	1.550	3.519	8.045
		China1	Log-Normal	1.415	1.299	2.945	6.765
		China2	Log-Normal	1.256	1.146	2.609	5.943
		China3	Log-Normal	0.745	0.697	1.555	3.567
		China4	Log-Normal	0.517	0.484	1.100	2.460
		China5	Log-Normal	0.517	0.484	1.100	2.460
	HDGPVs	China0	Log-Normal	2.223	2.100	4.741	10.559
		China1	Log-Normal	2.306	2.142	4.859	10.957
		China2	Log-Normal	0.852	0.788	1.805	4.030
		China3	Log-Normal	0.383	0.346	0.791	1.838
		China4	Log-Normal	0.184	0.167	0.380	0.872
		China5	Log-Normal	0.184	0.167	0.380	0.872
	HDDPVs	China0	Log-Normal	1.184	1.068	2.424	5.614
		China1	Log-Normal	0.254	0.234	0.532	1.211
		China2	Log-Normal	0.153	0.141	0.323	0.728
		China3	Log-Normal	0.122	0.114	0.260	0.583
		China4	Log-Normal	0.047	0.042	0.098	0.220
		China5	Log-Normal	0.024	0.021	0.050	0.112
	HDAPVs	China0	Log-Normal	1.694	1.550	3.519	8.045
		China1	Log-Normal	1.415	1.299	2.945	6.765
		China2	Log-Normal	1.256	1.146	2.609	5.943
China3		Log-Normal	0.745	0.697	1.555	3.567	
China4		Log-Normal	0.517	0.484	1.100	2.460	
China5		Log-Normal	0.517	0.484	1.100	2.460	
VKT of passenger vehicles in Beijing (Km)	LDGTAs	China0	Log-Normal	78550	38951	113204	330220
	LDDTAs	China0	Log-Normal	78550	38951	113204	330220
	LDATEs	China0	Log-Normal	78550	38951	113204	330220
	LDGPVs	China0	Log-Normal	7841	3973	11362	33524
	LDDPVs	China0	Log-Normal	7841	3973	11362	33524
	LDAPVs	China0	Log-Normal	7841	3973	11362	33524

	MDGBUs	China0	Log-Normal	4991	40260	50093	59910
	MDDBUs	China0	Log-Normal	4991	40260	50093	59910
	MDABUs	China0	Log-Normal	4991	40260	50093	59910
	MDGPVs	China0	Log-Normal	3143	25009	31310	37380
	MDDPVs	China0	Log-Normal	3143	25009	31310	37380
	MDAPVs	China0	Log-Normal	3143	25009	31310	37380
	HDGBUs	China0	Log-Normal	4991	40260	50093	59910
	HDDBUs	China0	Log-Normal	4991	40260	50093	59910
	HDABUs	China0	Log-Normal	4991	40260	50093	59910
	HDGPVs	China0	Log-Normal	11401	92557	114757	136940
	HDDPVs	China0	Log-Normal	11401	92557	114757	136940
	HDAPVs	China0	Log-Normal	11401	92557	114757	136940
VKT of passenger vehicles in other provinces (Km)	LDGTAs	China0	Log-Normal	78325	43077	120437	342273
	LDDTAs	China0	Log-Normal	78325	43077	120437	342273
	LDATEs	China0	Log-Normal	78325	43077	120437	342273
	LDGPVs	China0	Log-Normal	10796	6013	16571	46419
	LDDPVs	China0	Log-Normal	10796	6013	16571	46419
	LDAPVs	China0	Log-Normal	10796	6013	16571	46419
	MDGBUs	China0	Log-Normal	4991	40260	50093	59910
	MDDBUs	China0	Log-Normal	4991	40260	50093	59910
	MDABUs	China0	Log-Normal	4991	40260	50093	59910
	MDGPVs	China0	Log-Normal	3143	25009	31310	37380
	MDDPVs	China0	Log-Normal	3143	25009	31310	37380
	MDAPVs	China0	Log-Normal	3143	25009	31310	37380
	HDGBUs	China0	Log-Normal	4991	40260	50093	59910
	HDDBUs	China0	Log-Normal	4991	40260	50093	59910
HDABUs	China0	Log-Normal	4991	40260	50093	59910	
HDGPVs	China0	Log-Normal	11401	92557	114757	136940	
HDDPVs	China0	Log-Normal	11401	92557	114757	136940	
HDAPVs	China0	Log-Normal	11401	92557	114757	136940	
Emission factors on Urban road (g/Km)	LDGTs	China0	Normal	2.331	2.172	4.895	10.942
		China1	Normal	1.604	1.454	3.301	7.527
		China2	Normal	1.049	0.962	2.195	5.010
		China3	Normal	0.279	0.259	0.583	1.323
		China4	Normal	0.078	0.070	0.160	0.367
		China5	Normal	0.078	0.070	0.160	0.367
	MDGTs	China0	Normal	3.305	3.014	6.799	15.521
		China1	Normal	3.223	2.942	6.688	15.221
		China2	Normal	1.436	1.319	3.012	6.806

		China3	Normal	0.643	0.601	1.361	3.042	
		China4	Normal	0.275	0.249	0.561	1.307	
		China5	Normal	0.275	0.249	0.561	1.307	
	HDGTs	China0	Normal	3.200	2.955	6.680	15.063	
		China1	Normal	3.148	2.944	6.678	14.911	
		China2	Normal	1.393	1.346	2.989	6.689	
		China3	Normal	0.639	0.588	1.333	3.062	
		China4	Normal	0.261	0.245	0.550	1.242	
		China5	Normal	0.259	0.242	0.549	1.237	
	Emission factors on Provincial road (g/Km)	LDGTs	China0	Normal	1.774	1.657	3.728	8.432
			China1	Normal	1.182	1.107	2.497	5.675
China2			Normal	0.802	0.754	1.699	3.831	
China3			Normal	0.233	0.218	0.481	1.120	
China4			Normal	0.064	0.059	0.134	0.302	
China5			Normal	0.064	0.059	0.134	0.302	
MDGTs		China0	Normal	0.559	4.572	5.555	6.775	
		China1	Normal	2.399	2.225	5.036	11.250	
		China2	Normal	1.053	0.997	2.232	5.023	
		China3	Normal	0.486	0.453	1.025	2.268	
		China4	Normal	0.200	0.190	0.422	0.962	
		China5	Normal	0.200	0.190	0.422	0.962	
HDGTs		China0	Normal	2.402	2.198	4.985	11.389	
		China1	Normal	2.359	2.185	5.015	11.257	
		China2	Normal	1.099	0.983	2.252	5.223	
		China3	Normal	0.470	0.446	0.997	2.254	
		China4	Normal	0.045	0.368	0.447	0.543	
		China5	Normal	0.202	0.181	0.414	0.947	
Emission factors on National road (g/Km)	LDGTs	China0	Normal	1.902	1.789	3.988	9.089	
		China1	Normal	1.268	1.181	2.697	6.060	
		China2	Normal	0.846	0.775	1.764	3.999	
		China3	Normal	0.245	0.219	0.500	1.159	
		China4	Normal	0.066	0.062	0.138	0.317	
		China5	Normal	0.066	0.062	0.138	0.317	
	MDGTs	China0	Normal	2.612	2.461	5.547	12.615	
		China1	Normal	2.630	2.403	5.400	12.396	
		China2	Normal	1.150	1.070	2.424	5.444	
		China3	Normal	0.521	0.482	1.100	2.456	
		China4	Normal	0.218	0.201	0.461	1.031	
		China5	Normal	0.218	0.201	0.461	1.031	



	HDGTs	China0	Normal	2.575	2.427	5.430	12.302
		China1	Normal	2.639	2.391	5.387	12.523
		China2	Normal	1.140	1.072	2.415	5.435
		China3	Normal	0.513	0.484	1.088	2.454
		China4	Normal	0.215	0.199	0.446	1.020
		China5	Normal	0.211	0.198	0.449	0.997
Emission factors on Freeway (g/Km)	LDGTs	China0	Normal	1.801	1.691	3.760	8.437
		China1	Normal	1.219	1.121	2.542	5.812
		China2	Normal	0.808	0.746	1.688	3.817
		China3	Normal	0.237	0.214	0.487	1.117
		China4	Normal	0.065	0.059	0.136	0.309
		China5	Normal	0.065	0.059	0.136	0.309
	MDGTs	China0	Normal	2.525	2.249	5.277	11.911
		China1	Normal	2.418	2.264	5.101	11.534
		China2	Normal	1.086	1.003	2.296	5.215
		China3	Normal	0.487	0.457	1.048	2.313
		China4	Normal	0.207	0.188	0.431	0.993
		China5	Normal	0.207	0.188	0.431	0.993
	HDGTs	China0	Normal	2.410	2.242	5.132	11.470
		China1	Normal	2.430	2.327	5.150	11.495
		China2	Normal	1.089	0.992	2.282	5.249
		China3	Normal	0.485	0.456	1.029	2.318
		China4	Normal	0.203	0.182	0.420	0.968
		China5	Normal	0.198	0.187	0.418	0.941
Emission factors on other type roads (g/Km)	LDGTs	China0	Normal	3.066	2.829	6.411	14.780
		China1	Normal	1.994	1.857	4.246	9.496
		China2	Normal	1.370	1.238	2.848	6.525
		China3	Normal	0.352	0.320	0.734	1.679
		China4	Normal	0.094	0.089	0.204	0.452
		China5	Normal	0.094	0.089	0.204	0.452
	MDGTs	China0	Normal	4.173	3.949	8.844	20.062
		China1	Normal	4.122	3.823	8.777	19.875
		China2	Normal	1.900	1.707	3.882	9.052
		China3	Normal	0.839	0.781	1.759	3.984
		China4	Normal	0.357	0.325	0.738	1.709
		China5	Normal	0.357	0.325	0.738	1.709
	HDGTs	China0	Normal	4.102	3.794	8.706	19.494
		China1	Normal	4.055	3.828	8.734	19.229
		China2	Normal	1.847	1.712	3.882	8.921

		China3	Normal	0.843	0.771	1.744	3.988
		China4	Normal	0.336	0.322	0.715	1.600
		China5	Normal	0.344	0.317	0.720	1.632
Emission factors on urban road (g/Km)	LDDTs	China0	Normal	0.990	0.932	2.093	4.717
		China1	Normal	0.966	0.894	2.008	4.547
		China2	Normal	0.615	0.569	1.300	2.913
		China3	Normal	0.168	0.158	0.351	0.787
		China4	Normal	0.085	0.078	0.178	0.406
		China5	Normal	0.085	0.078	0.178	0.406
	MDDTs	China0	Normal	2.125	1.942	4.434	10.110
		China1	Normal	0.772	0.701	1.596	3.656
		China2	Normal	0.200	0.185	0.414	0.940
		China3	Normal	0.096	0.089	0.199	0.457
		China4	Normal	0.048	0.045	0.103	0.233
		China5	Normal	0.048	0.045	0.103	0.233
	HDDTs	China0	Normal	1.900	1.775	4.023	9.117
		China1	Normal	0.417	0.388	0.887	2.006
		China2	Normal	0.245	0.228	0.516	1.154
		China3	Normal	0.121	0.113	0.252	0.576
		China4	Normal	0.060	0.055	0.127	0.286
		China5	Normal	0.060	0.055	0.127	0.286
Emission factors on provincial road (g/Km)	LDDTs	China0	Normal	0.745	0.668	1.552	3.518
		China1	Normal	0.719	0.667	1.515	3.409
		China2	Normal	0.487	0.444	0.998	2.317
		China3	Normal	0.138	0.130	0.294	0.658
		China4	Normal	0.072	0.065	0.148	0.339
		China5	Normal	0.072	0.065	0.148	0.339
	MDDTs	China0	Normal	1.596	1.477	3.328	7.576
		China1	Normal	0.575	0.521	1.211	2.727
		China2	Normal	0.149	0.135	0.311	0.704
		China3	Normal	0.072	0.067	0.151	0.343
		China4	Normal	0.036	0.034	0.077	0.173
		China5	Normal	0.036	0.034	0.077	0.173
	HDDTs	China0	Normal	1.465	1.322	3.030	6.879
		China1	Normal	0.319	0.290	0.665	1.514
		China2	Normal	0.188	0.170	0.385	0.890
		China3	Normal	0.090	0.083	0.190	0.424
		China4	Normal	0.046	0.042	0.096	0.217
		China5	Normal	0.046	0.042	0.096	0.217

Emission factors on national road (g/Km)	LDDTs	China0	Normal	0.810	0.736	1.698	3.816
		China1	Normal	0.765	0.722	1.644	3.692
		China2	Normal	0.494	0.454	1.034	2.351
		China3	Normal	0.143	0.134	0.300	0.693
		China4	Normal	0.074	0.067	0.154	0.352
		China5	Normal	0.074	0.067	0.154	0.352
	MDDTs	China0	Normal	1.730	1.585	3.640	8.182
		China1	Normal	0.611	0.571	1.299	2.923
		China2	Normal	0.161	0.150	0.337	0.764
		China3	Normal	0.078	0.071	0.162	0.369
		China4	Normal	0.040	0.036	0.083	0.190
		China5	Normal	0.040	0.036	0.083	0.190
	HDDTs	China0	Normal	1.570	1.431	3.270	7.502
		China1	Normal	0.345	0.321	0.722	1.635
		China2	Normal	0.202	0.183	0.419	0.953
		China3	Normal	0.099	0.092	0.205	0.465
		China4	Normal	0.050	0.046	0.104	0.236
		China5	Normal	0.050	0.046	0.104	0.236
Emission factors on freeway (g/Km)	LDDTs	China0	Normal	0.757	0.696	1.593	3.582
		China1	Normal	0.715	0.699	1.555	3.487
		China2	Normal	0.480	0.433	0.983	2.249
		China3	Normal	0.141	0.132	0.297	0.677
		China4	Normal	0.071	0.066	0.148	0.336
		China5	Normal	0.071	0.066	0.148	0.336
	MDDTs	China0	Normal	1.639	1.506	3.402	7.777
		China1	Normal	0.582	0.529	1.221	2.748
		China2	Normal	0.153	0.141	0.322	0.724
		China3	Normal	0.073	0.067	0.154	0.345
		China4	Normal	0.037	0.034	0.078	0.175
		China5	Normal	0.037	0.034	0.078	0.175
	HDDTs	China0	Normal	1.456	1.328	3.075	6.925
		China1	Normal	0.324	0.301	0.682	1.522
		China2	Normal	0.187	0.175	0.394	0.892
		China3	Normal	0.021	0.173	0.210	0.255
		China4	Normal	0.046	0.044	0.097	0.219
		China5	Normal	0.046	0.044	0.097	0.219
Emission factors on	MDDTs	China0	Normal	1.286	1.182	2.694	6.171
		China1	Normal	1.214	1.176	2.635	5.828
		China2	Normal	0.793	0.732	1.667	3.801

other type roads (g/Km)		China3	Normal	0.208	0.192	0.439	0.992	
		China4	Normal	0.105	0.100	0.224	0.506	
		China5	Normal	0.105	0.100	0.224	0.506	
		China0	Normal	2.701	2.537	5.734	12.858	
	MDDTs	China1	Normal	0.972	0.928	2.080	4.628	
		China2	Normal	0.259	0.238	0.546	1.232	
		China3	Normal	0.126	0.115	0.260	0.594	
		China4	Normal	0.063	0.057	0.134	0.296	
		China5	Normal	0.063	0.057	0.134	0.296	
	HDDTs	China0	Normal	2.497	2.292	5.314	11.801	
		China1	Normal	0.561	0.517	1.170	2.649	
		China2	Normal	0.320	0.299	0.675	1.527	
		China3	Normal	0.156	0.149	0.328	0.749	
		China4	Normal	0.079	0.072	0.165	0.374	
		China5	Normal	0.079	0.072	0.165	0.374	
	VKT of freight trucks (Km)	LDGTs	China0	Normal	2231	17804	22144	26459
			China1	Normal	2231	17804	22144	26459
			China2	Normal	2613	21212	26282	31510
China3			Normal	2962	23701	29470	35296	
China4			Normal	3412	27517	34137	40880	
China5			Normal	3412	27517	34137	40880	
LDDTs		China0	Normal	1936	15457	19261	23046	
		China1	Normal	1936	15457	19261	23046	
		China2	Normal	2698	21680	26977	32181	
		China3	Normal	3642	29375	36624	43686	
		China4	Normal	4564	36264	45280	54401	
		China5	Normal	4564	36264	45280	54401	
MDGTs		China0	Normal	3523	28361	35216	42199	
		China1	Normal	3523	28361	35216	42199	
		China2	Normal	4003	32747	40789	48541	
		China3	Normal	4801	38505	47870	57236	
		China4	Normal	5273	43193	53491	63709	
		China5	Normal	5273	43193	53491	63709	
MDDTs		China0	Normal	2126	17035	21228	25407	
		China1	Normal	2126	17035	21228	25407	
		China2	Normal	2833	22651	28170	33692	
		China3	Normal	3616	29244	36345	43352	
		China4	Normal	5998	48661	60346	72179	
		China5	Normal	5998	48661	60346	72179	

	HDGTs	China0	Normal	2747	22236	27753	33098
		China1	Normal	2747	22236	27753	33098
		China2	Normal	3343	26601	33215	39661
		China3	Normal	4031	32340	40265	48241
		China4	Normal	4524	36913	45806	54752
		China5	Normal	4524	36913	45806	54752
	HDDTs	China0	Normal	2430	19566	24330	29119
		China1	Normal	2430	19566	24330	29119
		China2	Normal	3814	31028	38551	46017
		China3	Normal	6316	51858	64083	76300
		China4	Normal	9863	78952	98396	117258
		China5	Normal	9863	78952	98396	117258
Percentage of driving distance on different type roads	MDG(D)Ts	Urban road	Normal	0.010	0.219	0.239	0.258
		Provincial road	Normal	0.020	0.303	0.342	0.381
		National road	Normal	0.007	0.124	0.137	0.151
		Freeway	Normal	0.014	0.247	0.274	0.301
		others	Normal	0.000	0.007	0.008	0.009
	LDG(D)Ts	Urban road	Normal	0.020	0.314	0.353	0.392
		Provincial road	Normal	0.009	0.167	0.185	0.203
		National road	Normal	0.011	0.196	0.218	0.239
		Freeway	Normal	0.010	0.195	0.215	0.234
		others	Normal	0.001	0.028	0.031	0.034
	HDG(D)Ts	Urban road	Normal	0.007	0.128	0.142	0.155
		Provincial road	Normal	0.010	0.173	0.192	0.212
		National road	Normal	0.010	0.226	0.246	0.265
		Freeway	Normal	0.020	0.352	0.391	0.429
		others	Normal	0.002	0.027	0.030	0.033

34 **Table S8. Assignments from Real Compounds to Carbon Bond 05 (CB05) Model**

35 **Species for diesel exhaust, gasoline exhaust and evaporation in China (Gmol).**

	Diesel exhaust	Gasoline exhaust	Evaporation
PAR	7.179	39.017	72.452
OLE	0.371	0.994	1.380
TOL	0.217	2.389	0.507
XYL	0.222	1.035	0.189
FORM	4.425	2.700	0.215
ALD2	1.219	1.071	0.095
ETH	0.837	N.D.	0.017
ISOP	N.D.	N.D.	0.012
MEOH	N.D.	N.D.	N.D.
ETOH	N.D.	N.D.	N.D.
ETHA	N.D.	0.882	0.158
IOLE	N.D.	N.D.	2.046
ALDX	0.6852	1.309	0.128
TERP	N.D.	N.D.	N.D.
UNR	1.773	8.276	5.762

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38 **Table S9. Uncertainty range of emission inventories.**

		Unit	Mean	Standard division	C.V	The 95% confidence interval		
						2.5% percentile	50 percentile	97.5% percentile
Tailpipe emissions	Passenger vehicles tailpipe emissions	Gg	1279.12	252.51	0.20	902.39	1237.21	1891.96
	Trucks tailpipe emissions	Gg	720.89	45.20	0.06	636.52	718.39	816.43
	Motorcycles tailpipe emissions	Gg	562.54	349.17	0.62	158.61	476.40	1444.66
	Diurnal emissions (excluding motorcycles)	Gg	138.99	75.27	0.54	56.22	124.26	312.78
Evaporative emissions	Hot Soak emissions (excluding motorcycles)	Gg	15.75	3.71	0.24	9.70	15.33	24.26
	Refueling emissions	Gg	109.38	7.46	0.07	95.82	108.94	124.92
	Running loss	Gg	1146.18	768.92	0.67	229.90	963.11	3132.67
	Motorcycles evaporation	Gg	251.30	278.70	1.11	29.31	170.14	954.21
Ratio of evaporative emissions versus tailpipe emissions of passenger cars			1.14	0.67	0.5828	0.36	0.98	2.89
Total emissions		Gg	4224.14	943.21	0.22	2897.14	4053.82	6540.95

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41 **References:**

- 42 1. Liu, H.; Man, H.; Tschantz, M.; Wu, Y.; He, K.; Hao, J., VOC from Vehicular Evaporation  
43 Emissions: Status and Control Strategy. *Environ. Sci. Technol* **2015**, 49, (24), 14424-14431.  
44 DOI:10.1021/acs.est.5b04064
- 45 2. EPA-420-R-12-027; Development of Evaporative Emissions Calculations for the Motor Vehicle  
46 Emissions Simulator MOVES2010; United States Environmental Protection Agency; Washington,  
47 DC, **2012**; <https://nepis.epa.gov/Exe/ZyPDF.cgi/P100F3ZY.PDF?Dockey=P100F3ZY.PDF>
- 48 3. ICCT, Air Emissions Issues Related to Two and Three-Wheeled Motor Vehicles An Initial  
49 Assessment of Current Conditions and Options for Control; International Council on Clean  
50 Transportation (ICCT), 2007;  
51 [http://www.theicct.org/sites/default/files/publications/twothree\\_wheelers\\_2007.pdf](http://www.theicct.org/sites/default/files/publications/twothree_wheelers_2007.pdf)