

1 *Supplement of*  
2 **Multi-pollutants emissions from the burning of major agricultural**  
3 **residues in China and the related health-economic effect assessment**

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## Emission factors calculation method

Emission factors of smoke aerosol can be calculated based on filter sampling weight, sampling time, chamber volume, and actual amount of consumed fuel:

$$C_i = \frac{m_i}{v \times \Delta t} \times \varphi \quad (1)$$

$$EF_i = \frac{C_i \times V}{M} \quad (2)$$

Where  $C_i$  is suspend mass concentration of particulate species  $i$  in the aerosol chamber,

$m_i$  is blank corrected filter sampling weight of particulate species  $i$ ,

$v$  is flow rate of integrated sampler ( $100 \text{ L min}^{-1}$ );

$\Delta t$  is sampling time (5min),

$\varphi$  is correction factor with respect to dilution from makeup air during filter samplings,

$EF_i$  is emission factor of particulate species  $i$ ,

$V$  is chamber volume of  $4.5 \text{ m}^3$ ,

$M$  is effective amount of wheat straw burned ( $10.0 \text{ g}$  in this study).

As sampling makeup air and wall loss of smoke particle together dilute aerosol in the chamber, a differential function of particle concentration against time can established as:

$$dC = -C \times \left( \frac{v}{V} + \kappa \right) dt \quad (3)$$

$C_0$  is initial aerosol mass concentration in chamber,

$C$  is dynamic concentration as a result of sampling dilution and wall loss at time  $t$ ,  
 $t$  is the time when filter sampling starts from the initial time,

$\kappa$  is first-order wall loss coefficient of smoke particles in the chamber ( $\kappa \approx 2 \times 10^{-5} \text{ s}^{-1}$  calculated based on the work of Zhang et al (2011))

$\frac{v}{V}$  is first-order dilution coefficient from filter sampling,  $v$  is sampling flow,  $V$  is

chamber volume, and  $\frac{v}{V}$  equals  $3.7 \times 10^{-4} \text{ s}^{-1}$

The calculated dynamic aerosol concentration was described as equation 4:

$$C = C_0 \times e^{-\left(\frac{v}{V} + \kappa\right)t} \quad (4)$$

Effective filter sampling weight of  $\text{PM}_{1.0}$  or  $\text{PM}_{2.5}$  should equal to the integration of dynamic concentration with sampling time and sampling flow as equation 5:

$$m = \frac{C_0}{\frac{v}{V} + \kappa} \times v \times \left[ e^{-\left(\frac{v}{V} + \kappa\right)t} - e^{-\left(\frac{v}{V} + \kappa\right)(t + \Delta t)} \right] = C_0 \times v \times \Delta t \times \varphi \quad (5)$$

$m$  is filter sampling mass weighted by the balance,  $\Delta t$  is sampling duration time (5 min),  $\varphi$  is correction factor for sampling.

Therefore, the emission factor of  $\text{PM}_{1.0}$  and  $\text{PM}_{2.5}$  from specific crop straw burning can be calculated following equation 6:

$$EF = \frac{m \times V}{v \times \Delta t \times \varphi \times m_c} \quad (6)$$

Where  $m_c$  is consumed effective mass of crop straw (unburned residue deducted from  $10.0 \text{ g}$ ).

Combining chemical fractions, emission factor of particulate species can also be derived from emission factor of PM<sub>1.0</sub> and PM<sub>2.5</sub>.

$$\kappa \ll \frac{v}{V}, \quad \varphi \approx \frac{\frac{v}{V} \times \Delta t}{e^{-\frac{v}{V} \times t} - e^{-\frac{v}{V} \times (t + \Delta t)}}$$

The first PM<sub>1.0</sub> filter sampling start at initial time, followed by the second PM<sub>2.5</sub> sampling at 8~10 min from the initial time during one chamber test. According the equation above, the first correction coefficient is 1.06, while the second one is 1.32.

**Table S1.** Parameters in emission inventory calculation.

Type of agricultural residue	Production to residue ratio (r) <sup>a</sup>	Dry matter fraction (D) <sup>b</sup>	Burn efficiency (f) <sup>c</sup>
Wheat straw	1.37	0.865	0.93
Corn straw	2.00	0.850	0.93
Rice straw	0.62	0.940	0.93
Cotton residue	3.00	0.850	0.93
Soybean residue	1.50	0.897	0.68 <sup>d</sup>

a. Data from Chinese Association of Rural Energy Industry (CAREI,2000, data available at <http://www.carei.org.cn/index.php>);

b. Data from He et al., 2011; IPCC, 2007)

c. Zhang et al., 2011; Wang et al., 2008; Zhang et al., 2008; and also confirmed by this study

d. Koopmans et al., 1997

69 **Table S2.**Temporal-spatial distribution of crop production in form of production ratio  
70 in China.

Province	Summer harvest					Autumn harvest				
	Wheat <sup>a</sup>	Corn <sup>b</sup>	Rice <sup>c</sup>	Cotton <sup>d</sup>	Soybean <sup>e</sup>	Wheat <sup>a</sup>	Corn <sup>b</sup>	Rice <sup>c</sup>	Cotton <sup>d</sup>	Soybean <sup>e</sup>
Beijing	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Tianjin	0.94	0.00	0.00	0.00	0.00	0.06	1.00	1.00	1.00	1.00
Hebei	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Shanxi	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Inner Mongolia	0.05	0.00	0.03	0.00	0.00	0.95	1.00	0.97	1.00	1.00
Liaoning	0.05	0.00	0.00	0.00	0.00	0.95	1.00	1.00	1.00	1.00
Jilin	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00
Heilongjiang	0.05	0.00	0.00	None	0.00	0.95	1.00	1.00	None	1.00
Shanghai	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Jiangsu	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Zhejiang	1.00	0.00	0.09	0.00	0.00	0.00	1.00	0.91	1.00	1.00
Anhui	1.00	0.00	0.10	0.00	0.00	0.00	1.00	0.90	1.00	1.00
Fujian	1.00	0.00	0.25	None	0.00	0.00	1.00	0.75	None	1.00
Jiangxi	0.95	0.00	0.40	0.00	0.00	0.05	1.00	0.60	1.00	1.00
Shandong	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Henan	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Hubei	1.00	0.00	0.15	0.00	0.00	0.00	1.00	0.85	1.00	1.00
Hunan	1.00	0.00	0.30	0.00	0.00	0.00	1.00	0.70	1.00	1.00
Guangdong	1.00	0.00	0.47	None	0.00	0.00	1.00	0.53	None	1.00
Guangxi	1.00	0.00	0.47	0.00	0.00	0.00	1.00	0.53	1.00	1.00
Hainan	0.00	0.00	0.45	None	0.00	1.00	1.00	0.55	None	1.00
Chongqing	1.00	0.00	0.00	None	0.00	0.00	1.00	1.00	None	1.00
Sichuan	0.99	0.00	0.00	0.00	0.00	0.01	1.00	1.00	1.00	1.00
Guizhou	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Yunnan	0.95	0.00	0.06	None	0.00	0.05	1.00	0.94	None	1.00
Tibet	0.75	0.00	0.00	None	0.00	0.25	1.00	1.00	None	1.00
Shannxi	1.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
Gansu	0.65	0.00	None	0.00	0.00	0.35	1.00	None	1.00	1.00
Qinghai	0.00	0.00	None	None	0.00	1.00	1.00	None	None	1.00
Ningxia	0.00	0.00	0.00	None	0.00	1.00	1.00	1.00	None	1.00
Xinjiang	0.66	0.00	0.00	0.00	0.00	0.34	1.00	1.00	1.00	1.00

71 *None means no such crop grows in the province from agricultural documents*

72 *a. Data of winter wheat (sowing time: winter)and spring wheat(sowing time: spring) production*  
73 *from China Grain Yearbook 2013(National Bureau of Statistics of China, NBSC, 2013)*

74 *b. Data of spring corn(harvest time: autumn) and summer corn (harvest time: late autumn)*  
75 *production from China Grain Yearbook 2013 (NBSC, 2013)*

76 *c. Data of early, middle, and late rice production from China Grain Yearbook of 2013, Journal*  
77 *of China Rice 2011, and Chinese Journal of Rice Science (NBSC, 2013)*

78 *d. Data of cotton harvest and production area from China Yearbook(2012~2014) and from*  
79 *website of <http://www.cncotton.com/> (NBSC, 2013)*

80 e. *Data of soybean harvest and production from China Yearbook(2012~2014) and China Grain*  
81 *Yearbook 2013 (NBSC, 2013)*  
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83 **Table S3.** Summary of carcinogenic UnitRisk for selected HAPs.

<i>Elements</i>	Carcinogenic risk factor (unit: per $\mu\text{g m}^{-3}$ )
As	4.30E-03 <sup>a</sup>
Zn	—
Pb	1.20E-05 <sup>a</sup>
Cd	1.80E-03 <sup>a</sup>
Ni	4.80E-04 <sup>a</sup>
Cr	2.40E-03 <sup>a</sup>
V	—
Al	—
<i>PAHs</i>	Carcinogenic risk factor (unit: per $\mu\text{g m}^{-3}$ )
naphthalene	3.40E-05 <sup>b</sup>
acenaphthylene	1.10E-06 <sup>c</sup>
acenaphthene	1.10E-06 <sup>c</sup>
flourene	1.10E-06 <sup>c</sup>
anthracene	1.10E-05 <sup>c</sup>
phenathrene	1.10E-06 <sup>c</sup>
flouranthene	1.10E-06 <sup>c</sup>
pyrene	1.10E-06 <sup>c</sup>
benz(a)anthracene	1.10E-04 <sup>b</sup>
chrysene	1.10E-05 <sup>b</sup>
benzo(a)pyrene	1.10E-03 <sup>b</sup>
benzo(b)flouranthene	1.10E-04 <sup>b</sup>
benzo(k)flouranthene	1.10E-04 <sup>b</sup>
benzo(g,h,i)pyrene	1.10E-05 <sup>c</sup>
indeno(1,2,3-cd)pyrene	1.10E-04 <sup>b</sup>
dibenz(a,h)anthracene	1.20E-03 <sup>b</sup>

84 <sup>a</sup> Reference from the Integrated Risk Information System (IRIS), data available at website:  
85 <http://www.epa.gov/iris/index.html>

86 <sup>b</sup> Reference from Cal EPA, data available at  
87 website:[http://www.oehha.ca.gov/air/hot\\_spots/pdf/May2005Hotspots.pdf](http://www.oehha.ca.gov/air/hot_spots/pdf/May2005Hotspots.pdf)

88 <sup>c</sup> Reference from Nisbet et al., 1992

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90 **Table S4.** Exposure-response coefficients for individual mortality (per 10  $\mu\text{g m}^{-3}$  95%  
91 CI).

Province (Research Region)	$\beta$ (95% CI)	References <sup>a</sup>
<b>Beijing</b>	0.53 (0.37, 0.69)	Chen et al., 2011, Xu et al., 2014, Gao et al., 2015
<b>Tianjin</b>	0.77 (0.44, 1.10)	Chen et al., 2012
<b>Hebei (Tangshan)</b>	0.09 (-0.40, 0.58)	Chen et al., 2012
<b>Shanxi (Taiyuan)</b>	0.19 (0.03, 0.35)	Zhang et al., 2007, Chen et al., 2012
<b>Inner Mongolia</b>	0.19 (0.03, 0.35)	Hou et al., 2012
<b>Liaoning (Shenyang)</b>	0.49 (0.19, 0.79)	Chen et al., 2011, Ma et al., 2011
<b>Jilin</b>	0.49 (0.19, 0.79)	Hou et al., 2012
<b>Heilongjiang</b>	0.49 (0.19, 0.79)	Hou et al., 2012
<b>Shanghai</b>	0.28 (0.10, 0.46)	Chen et al., 2011, Kan et al., 2007, Wong et al., 2008
<b>Jiangsu (Suzhou)</b>	0.36 (0.19, 0.53)	Chen et al., 2012
<b>Zhejiang (Hangzhou)</b>	0.31 (0.07, 0.55)	Chen et al., 2012
<b>Anhui</b>	0.36 (0.19, 0.53)	Hou et al., 2012
<b>Fujian (Fuzhou)</b>	0.61 (0.19, 1.03)	Hou et al., 2012, Chen et al., 2012
<b>Jiangxi</b>	0.36 (0.19, 0.53)	Hou et al., 2012
<b>Shandong</b>	0.28 (0.10, 0.46)	Hou et al., 2012
<b>Henan</b>	0.36 (0.19, 0.53)	Hou et al., 2012
<b>Hubei (Wuhan)</b>	0.36 (0.19, 0.53)	Hou et al., 2012, Chen et al., 2012, Wong et al., 2008
<b>Hunan</b>	0.36 (0.19, 0.53)	Hou et al., 2012
<b>Guangdong (Guangzhou)</b>	0.90 (0.55, 1.26)	Hou et al., 2012, Yang et al., 2012
<b>Guangxi</b>	0.36 (0.19, 0.53)	Hou et al., 2012
<b>Hainan</b>	0.36 (0.19, 0.53)	Hou et al., 2012
<b>Chongqing</b>	0.36 (0.19, 0.53)	Hou et al., 2012
<b>Sichuan</b>	0.36 (0.19, 0.53)	Hou et al., 2012
<b>Guizhou</b>	0.36 (0.19, 0.53)	Hou et al., 2012
<b>Yunnan</b>	0.36 (0.19, 0.53)	Hou et al., 2012
<b>Tibet</b>	0.19 (0.03, 0.35)	Hou et al., 2012
<b>Shannxi (Xi'an)</b>	0.20 (0.10, 0.30)	Cao et al., 2012
<b>Gansu (Lanzhou)</b>	0.05 (-0.10, 0.20)	Chen et al., 2012
<b>Qinghai</b>	0.19 (0.03, 0.35)	Hou et al., 2012
<b>Ningxia</b>	0.19 (0.03, 0.35)	Hou et al., 2012
<b>Xinjiang (Urumqi)</b>	0.10 (-0.10, 0.30)	Chen et al., 2012

92 <sup>a</sup> Cao et al., 2012; Chen et al., 2011; Chen et al., 2012; Gao et al., 2015; Hou et al., 2012; Kan et al.,  
93 2007; Ma et al., 2011; Wong et al., 2008; Xu et al., 2014; Yang et al., 2012; Zhang et al., 2007

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95 **Table S5.** Regional human capital value.

Region	Population (10 <sup>4</sup> ) <sup>a</sup>	GDP ( billion RMB ) <sup>a</sup>	HC ( US\$ )
Beijing	2069	1780.1	342252.3
Tianjin	1413	1288.52	362753.4
Hebei	7288	2657.5	145053.2
Shanxi	3611	1211.28	133438.0
Inner Mongolia	2490	1598.83	255426.2
Liaoning	4389	2480.13	224787.1
Jilin	2750	1193.78	172684.8
Heilongjiang	3834	1369.16	142057.6
Shanghai	2380	2010.13	335977.1
Jiangsu	7920	5405.82	271518.2
Zhejiang	5477	3460.63	251347.7
Anhui	5988	1721.21	114344.3
Fujian	3748	1970.18	209107.1
Jiangxi	4504	1294.85	114362.5
Shandong	9685	5001.32	205422.3
Henan	9406	2981.01	126072.7
Hubei	5779	2225.02	153159.4
Hunan	6639	2215.42	132744.3
Guangdong	10594	5706.79	214286.3
Guangxi	4682	1303.1	110715.6
Hainan	887	285.53	128053.3
Chongqing	2945	1145.9	154783.2
Sichuan	8076	2384.98	117476.5
Guizhou	3484	680.22	77666.5
Yunnan	4659	1030.98	88027.8
Tibet	308	69.56	89840.3
Shannxi	3763	1445.12	152767.9
Gansu	2578	565.02	87185.3
Qinghai	573	188.45	130829.0
Ningxia	647	232.66	143047.4
Xinjiang	2233	746.63	133008.4

96 <sup>a</sup> NBSC, 2013, data available at <http://www.stats.gov.cn/tjsj/ndsj/>, in Chinese

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98 **Table S6.** Relevance matrix of multi-pollutants in PM<sub>2.5</sub> and PM<sub>1.0</sub> from agricultural residue burning.

		PM <sub>2.5</sub>	PM <sub>1.0</sub>	PM <sub>2.5</sub>				PM <sub>1.0</sub>				PAHs		Phenols		Organic acids		Aminium	
				OC	EC	char-EC	soot-EC	OC	EC	char-EC	soot-EC	PM <sub>2.5</sub>	PM <sub>1.0</sub>	PM <sub>2.5</sub>	PM <sub>1.0</sub>	PM <sub>2.5</sub>	PM <sub>1.0</sub>	PM <sub>2.5</sub>	PM <sub>1.0</sub>
PM <sub>2.5</sub>		1.000	<b>0.995</b>	<b>0.993</b>	0.675	0.730	0.472	<b>0.994</b>	0.603	0.661	0.380	<b>0.951</b>	<b>0.923</b>	0.687	0.611	<b>0.877</b>	<b>0.846</b>	0.760	0.760
PM <sub>1.0</sub>			1.000	<b>0.982</b>	0.736	0.787	0.540	<b>0.993</b>	0.669	0.723	0.446	<b>0.973</b>	<b>0.950</b>	0.644	0.600	<b>0.844</b>	<b>0.805</b>	0.760	0.752
PM <sub>2.5</sub>	OC			1.000	0.633	0.692	0.420	<b>0.996</b>	0.560	0.625	0.326	<b>0.927</b>	<b>0.900</b>	0.729	0.635	<b>0.921</b>	<b>0.890</b>	0.738	0.739
	EC				1.000	<b>0.996</b>	0.714	0.695	<b>0.994</b>	<b>0.997</b>	0.790	<b>0.842</b>	<b>0.885</b>	0.179	0.251	0.431	0.385	0.489	0.433
	char-EC					1.000	0.638	0.750	<b>0.979</b>	<b>0.993</b>	0.790	<b>0.898</b>	<b>0.923</b>	0.222	0.284	0.510	0.451	0.539	0.485
	soot-EC						1.000	0.488	<b>0.978</b>	<b>0.949</b>	<b>0.885</b>	0.681	0.714	0.144	0.147	0.234	0.186	0.294	0.238
PM <sub>1.0</sub>	OC							1.000	0.625	0.687	0.388	<b>0.955</b>	<b>0.933</b>	0.687	0.623	<b>0.894</b>	<b>0.858</b>	0.745	0.739
	EC								1.000	<b>0.994</b>	<b>0.869</b>	<b>0.800</b>	<b>0.831</b>	0.135	0.218	0.370	0.313	0.418	0.360
	char-EC									1.000	0.782	<b>0.846</b>	<b>0.876</b>	0.243	0.255	0.443	0.384	0.468	0.411
	soot-EC										1.000	0.585	0.616	0.027	0.100	0.147	0.109	0.207	0.155
PAHs	PM <sub>2.5</sub>											1.000	<b>0.896</b>	0.488	0.473	0.776	0.728	0.736	0.710
	PM <sub>1.0</sub>												1.000	0.387	0.419	0.760	0.710	0.713	0.680
Phenols	PM <sub>2.5</sub>													1.000	<b>0.890</b>	0.712	0.712	0.373	0.414
	PM <sub>1.0</sub>														1.000	0.511	0.485	0.302	0.328
Organic acids	PM <sub>2.5</sub>															1.000	<b>0.895</b>	0.762	0.608
	PM <sub>1.0</sub>																1.000	0.569	0.741
Aminium	PM <sub>2.5</sub>																	1.000	<b>0.936</b>
	PM <sub>1.0</sub>																		1.000

**Table S7.** Summary of field burning rates in China.

Province	Burning rate from literature		Estimated burning rate		NDRC report <sup>d</sup>	Carcinogenic Risk
	BAU-I <sup>a</sup>	BAU-II <sup>b</sup>	EM-I	EM-II	NDRC	CRC
Beijing	0.00	0.17	0.00	0.19	0.13	0.02
Tianjin	0.00	0.17	0.00	0.20	0.30	0.01
Hebei	0.20	0.17	0.22	0.16	0.19	0.01
Shanxi	0.20	0.17	0.16	0.14	0.22	0.02
Inner Mongolia	0.00	0.12	0.00	0.09	0.27	0.10
Liaoning	0.20	0.12	0.16	0.09	0.34	0.01
Jilin	0.30	0.12	0.28	0.11	0.25	0.01
Heilongjiang	0.30	0.12	0.50	0.17	0.25	0.02
Shanghai	0.00	0.32	0.00	0.29	0.12	0.01
Jiangsu	0.30	0.32	0.32	0.23	0.19	0.01
Zhejiang	0.30	0.32	0.64	0.28	0.22	0.04
Anhui	0.20	0.32	0.21	0.29	0.43	0.01
Fujian	0.30	0.32	0.39	0.22	0.17	0.06
Jiangxi	0.20	0.11	0.20	0.08	0.25	0.02
Shandong	0.30	0.17	0.40	0.17	0.21	0.01
Henan	0.20	0.17	0.23	0.18	0.22	0.01
Hubei	0.20	0.11	0.21	0.08	0.30	0.02
Hunan	0.20	0.33	0.22	0.24	0.35	0.02
Guangdong	0.30	0.33	0.44	0.25	0.18	0.04
Guangxi	0.20	0.33	0.25	0.25	0.35	0.04
Hainan	0.30	0.33	0.51	0.25	0.56	0.06
Chongqing	0.20	0.11	0.24	0.08	0.45	0.02
Sichuan	0.20	0.11	0.26	0.09	0.30	0.04
Guizhou	0.20	0.11	0.31	0.10	0.43	0.05
Yunnan	0.20	0.11	0.24	0.09	0.28	0.05
Tibet	0.00	0.16	0.00	0.30	0.16	1.00
Shannxi	0.20	0.17	0.25	0.18	0.28	0.03
Gansu	0.10	0.16	0.09	0.11	0.33	0.09
Qinghai	0.00	0.16	0.00	0.20	0.28	1.00
Ningxia	0.10	0.16	0.09	0.13	0.16	0.03
Xinjiang	0.10	0.16	0.06	0.13	0.30	0.19
Nationwide	<b>0.21</b>	<b>0.16</b>	<b>0.26</b>	<b>0.15</b>	<b>0.27</b>	<b>0.03</b>

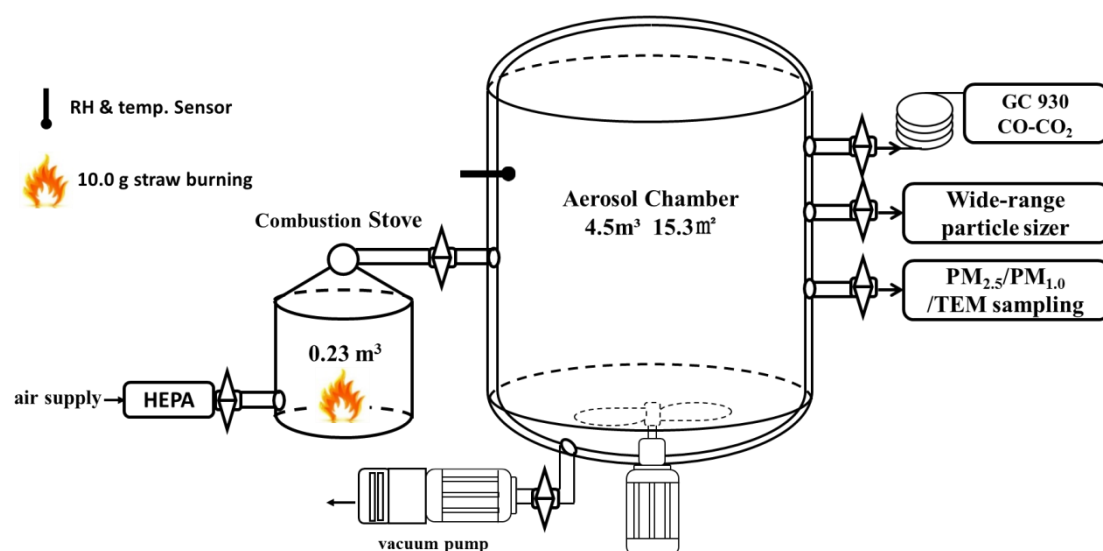
- 100 a. Zhao et al., 2012; Cao et al., 2006; Cao et al., 2011
- b. Wang et al., 2008
- c. Calculated based on data from China Yearbook 2001~2013 (NBSC, 2001-2013), China Rural Statistic Yearbook 2001~2013, data available at <http://www.grain.gov.cn/Grain/>
- 105 d. Data from the National Development and Reform Commission report ((2014)No.516) : <http://www.sdpc.gov.cn/>

**Table S8.** Regional health impact estimated from agricultural straw field burning PM<sub>2.5</sub> exposure in 2012 (95%CI).

Region	Mortality	Respiratory hospital admission	Cardiovascular hospital admission	Chronic bronchitis
Beijing	15 (9 , 19)	64 (59 , 116)	107 (46 , 167)	29710 (10368 , 47471)
Tianjin	120 (59 , 171)	172 (154 , 300)	215 (93 , 333)	57476 (21782 , 85289)
Hebei	119 (0 , 763)	1405 (1204 , 2360)	1677 (726 , 2608)	466659 (171730 , 709481)
Shanxi	47 (6 , 87)	282 (260 , 513)	361 (156 , 564)	106087 (37488 , 167523)
Inner Mongolia	5 (1 , 9)	23 (23 , 45)	31 (13 , 49)	9656 (3294 , 15773)
Liaoning	283 (94 , 455)	568 (568 , 1097)	793 (346 , 1224)	202625 (79397 , 292290)
Jilin	232 (77 , 371)	512 (512 , 976)	715 (314 , 1097)	169765 (70257 , 233621)
Heilongjiang	297 (99 , 477)	610 (610 , 1168)	852 (373 , 1309)	207490 (84192 , 291072)
Shanghai	15 (5 , 25)	318 (291 , 562)	406 (177 , 627)	103495 (40632 , 149294)
Jiangsu	1338 (604 , 1968)	3597 (3152 , 5970)	4408 (1943 , 6739)	1010935 (428630 , 1370199)
Zhejiang	177 (34 , 316)	665 (626 , 1224)	873 (378 , 1355)	239418 (88994 , 361723)
Anhui	654 (294 , 965)	2187 (1833 , 3528)	2559 (1118 , 3944)	640984 (254957 , 911232)
Fujian	123 (33 , 210)	257 (228 , 452)	317 (137 , 496)	94774 (33064 , 151497)
Jiangxi	169 (76 , 251)	561 (466 , 920)	649 (280 , 1013)	188513 (67183 , 295274)
Shandong	1034 (316 , 1700)	4079 (3418 , 6530)	4775 (2095 , 7332)	1148305 (470450 , 1596069)
Henan	1088 (489 , 1607)	3622 (2917 , 5633)	4070 (1776 , 6283)	1036093 (407513 , 1482407)
Hubei	248 (111 , 368)	761 (682 , 1337)	950 (411 , 1478)	265622 (97362 , 406040)
Hunan	492 (221 , 728)	1370 (1198 , 2338)	1670 (725 , 2591)	453314 (169872 , 678779)
Guangdong	704 (366 , 991)	1319 (1077 , 2127)	1497 (646 , 2339)	438230 (155315 , 689872)
Guangxi	144 (64 , 214)	468 (392 , 775)	545 (235 , 852)	161580 (56682 , 256861)
Hainan	29 (13 , 43)	101 (83 , 164)	116 (50 , 181)	34011 (12014 , 53715)
Chongqing	127 (57 , 188)	318 (311 , 604)	433 (188 , 671)	114855 (43778 , 169916)
Sichuan	180 (81 , 268)	461 (431 , 853)	600 (258 , 937)	177341 (62349 , 281457)
Guizhou	70 (31 , 104)	170 (164 , 325)	229 (99 , 357)	67131 (23740 , 105970)
Yunnan	68 (30 , 101)	177 (171 , 338)	237 (102 , 371)	71278 (24758 , 114413)
Tibet	0 (0 , 0)	0 (0 , 0)	0 (0 , 0)	18 (6 , 29)
Shannxi	45 (19 , 69)	256 (221 , 439)	307 (132 , 481)	92553 (32094 , 148790)
Gansu	2 (0 , 9)	44 (40 , 80)	56 (24 , 88)	17339 (5888 , 28453)
Qinghai	0 (0 , 0)	0 (0 , 0)	0 (0 , 1)	107 (36 , 178)
Ningxia	4 (1 , 7)	26 (26 , 51)	36 (16 , 56)	10744 (3756 , 17133)
Xinjiang	2 (0 , 7)	28 (27 , 53)	37 (16 , 58)	11528 (3905 , 18962)

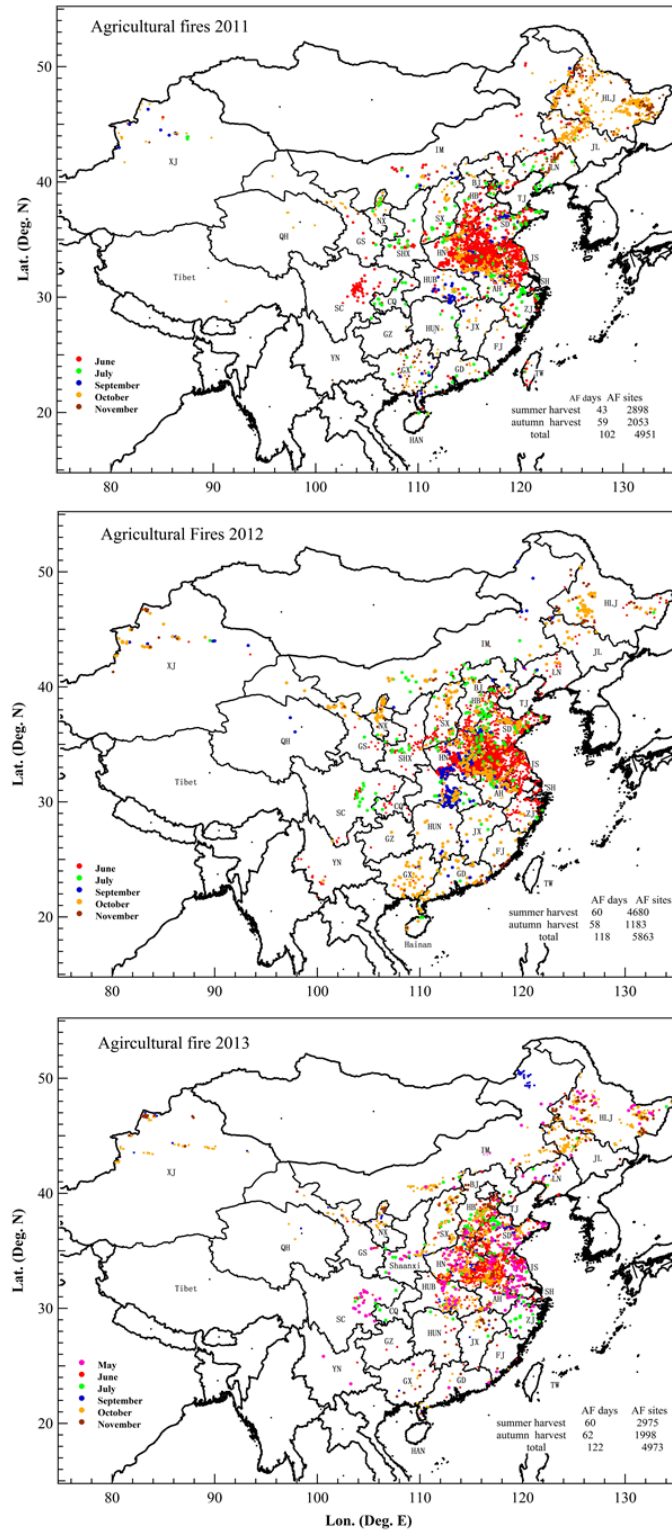
**110 Table S9.** Regional health-related economic losses estimated from agricultural straw field burning PM<sub>2.5</sub> exposure in 2012 (95%CI).

Region	Mortality (million US\$)	Respiratory hospital admission (US\$)	Cardiovascular hospital admission (US\$)	Chronic bronchitis (million US\$)	Total (million US\$)	GDP ratio (%)
Beijing	5.0 (2.9 , 6.6)	40721 (37149 , 73633)	130813 (56316 , 204641)	28.2 (9.8 , 45.0)	33.3 (12.9 , 51.9)	0.01 (0.00 , 0.02)
Tianjin	43.5 (21.3 , 62.1)	108882 (97509 , 189735)	262986 (114290 , 407592)	54.5 (20.7 , 80.9)	98.4 (42.1 , 143.6)	0.05 (0.02 , 0.07)
Hebei	17.2 (0.0 , 110.6)	888441 (761317 , 1491698)	2051480 (888352 , 3190721)	442.7 (162.9 , 673.0)	462.8 (164.6 , 788.3)	0.12 (0.04 , 0.20)
Shanxi	6.2 (0.8 , 11.6)	178215 (164136 , 324460)	441797 (190457 , 690200)	100.6 (35.6 , 158.9)	107.5 (36.7 , 171.5)	0.06 (0.02 , 0.09)
Inner Mongolia	1.2 (0.2 , 2.2)	14280 (14270 , 28422)	38373 (16479 , 60175)	9.2 (3.1 , 15.0)	10.4 (3.3 , 17.2)	0.00 (0.00 , 0.01)
Liaoning	63.6 (21.1 , 102.2)	359343 (359343 , 693770)	970126 (423305 , 1497619)	192.2 (75.3 , 277.3)	257.1 (97.2 , 381.7)	0.07 (0.03 , 0.10)
Jilin	40.0 (13.4 , 64.1)	323592 (323592 , 617007)	874992 (384236 , 1342282)	161.0 (66.6 , 221.6)	202.3 (80.7 , 287.7)	0.11 (0.05 , 0.16)
Heilongjiang	42.2 (14.1 , 67.7)	385730 (385583 , 738158)	1042099 (456717 , 1601816)	196.8 (79.9 , 276.1)	240.5 (94.8 , 346.1)	0.12 (0.05 , 0.17)
Shanghai	5.0 (1.5 , 8.3)	200883 (184058 , 355126)	496947 (216914 , 766900)	98.2 (38.5 , 141.6)	103.9 (40.5 , 151.0)	0.03 (0.01 , 0.05)
Jiangsu	363.3 (164.0 , 534.4)	2274302 (1992690 , 3774133)	5392964 (2376775 , 8244488)	959.0 (406.6 , 1299.8)	1330.0 (575.0 , 1846.2)	0.16 (0.07 , 0.23)
Zhejiang	44.6 (8.6 , 79.4)	420606 (396020 , 773845)	1067513 (462934 , 1658015)	227.1 (84.4 , 343.1)	273.2 (93.8 , 425.0)	0.05 (0.02 , 0.08)
Anhui	74.8 (33.6 , 110.3)	1382389 (1159039 , 2230692)	3130315 (1368032 , 4824791)	608.0 (241.9 , 864.4)	687.3 (278.0 , 981.8)	0.27 (0.11 , 0.38)
Fujian	25.8 (6.8 , 43.9)	162775 (144204 , 285846)	388013 (167038 , 607014)	89.9 (31.4 , 143.7)	116.3 (38.5 , 188.5)	0.04 (0.01 , 0.06)
Jiangxi	19.4 (8.7 , 28.8)	354421 (294904 , 581896)	793958 (342586 , 1239231)	178.8 (63.7 , 280.1)	199.3 (73.0 , 310.7)	0.10 (0.04 , 0.16)
Shandong	212.4 (64.8 , 349.1)	2578998 (2160860 , 4128186)	5841581 (2562845 , 8969803)	1089.3 (446.3 , 1514.0)	1310.1 (515.8 , 1876.3)	0.18 (0.07 , 0.25)
Henan	137.2 (61.7 , 202.6)	2289963 (1844372 , 3561044)	4979163 (2172280 , 7687121)	982.8 (386.6 , 1406.2)	1127.3 (452.3 , 1620.1)	0.25 (0.10 , 0.36)
Hubei	38.0 (17.0 , 56.4)	481134 (431260 , 845488)	1162015 (503058 , 1807812)	252.0 (92.4 , 385.2)	291.6 (110.3 , 444.2)	0.09 (0.03 , 0.13)
Hunan	65.3 (29.3 , 96.7)	866185 (757567 , 1478074)	2042478 (886386 , 3169909)	430.0 (161.1 , 643.9)	498.2 (192.1 , 745.2)	0.15 (0.06 , 0.23)
Guangdong	150.9 (78.4 , 212.4)	833689 (680589 , 1344575)	1832040 (790016 , 2861271)	415.7 (147.3 , 654.4)	569.3 (227.2 , 871.0)	0.07 (0.03 , 0.10)
Guangxi	15.9 (7.1 , 23.6)	295937 (247606 , 490254)	666332 (287017 , 1041828)	153.3 (53.8 , 243.7)	170.2 (61.4 , 268.8)	0.09 (0.03 , 0.14)
Hainan	3.7 (1.7 , 5.5)	63968 (52592 , 103975)	141558 (61021 , 221163)	32.3 (11.4 , 51.0)	36.2 (13.2 , 56.8)	0.08 (0.03 , 0.13)
Chongqing	19.6 (8.8 , 29.1)	200727 (196426 , 381574)	529883 (230486 , 820541)	109.0 (41.5 , 161.2)	129.3 (50.8 , 191.4)	0.08 (0.03 , 0.11)
Sichuan	21.2 (9.5 , 31.4)	291401 (272575 , 539393)	733579 (316074 , 1146647)	168.2 (59.1 , 267.0)	190.4 (69.2 , 300.1)	0.05 (0.02 , 0.08)
Guizhou	5.5 (2.4 , 8.1)	107293 (103976 , 205490)	279873 (120667 , 437183)	63.7 (22.5 , 100.5)	69.5 (25.2 , 109.3)	0.07 (0.02 , 0.11)
Yunnan	6.0 (2.7 , 8.8)	112205 (107835 , 213955)	290117 (124835 , 454081)	67.6 (23.5 , 108.5)	74.0 (26.4 , 118.0)	0.05 (0.02 , 0.08)
Tibet	0	0	0	0	0	0
Shannxi	6.9 (2.9 , 10.5)	162010 (139712 , 277308)	375863 (161700 , 588397)	87.8 (30.4 , 141.1)	95.2 (33.7 , 152.5)	0.04 (0.02 , 0.07)
Gansu	0.2 (0.0 , 0.8)	27839 (25471 , 50782)	68487 (29398 , 107451)	16.4 (5.6 , 27.0)	16.7 (5.6 , 27.9)	0.02 (0.01 , 0.03)
Qinghai	0.0 (0.0 , 0.0)	155 (155 , 309)	415 (178 , 653)	0.1 (0.0 , 0.2)	0.1 (0.0 , 0.2)	0.00 (0.00 , 0.00)
Ningxia	0.6 (0.1 , 1.1)	16392 (16392 , 32479)	44108 (18992 , 68990)	10.2 (3.6 , 16.3)	10.8 (3.7 , 17.4)	0.03 (0.01 , 0.05)
Xinjiang	0.3 (0.0 , 1.0)	17981 (16881 , 33672)	45386 (19477 , 71226)	10.9 (3.7 , 18.0)	11.3 (3.7 , 19.1)	0.01 (0.00 , 0.02)

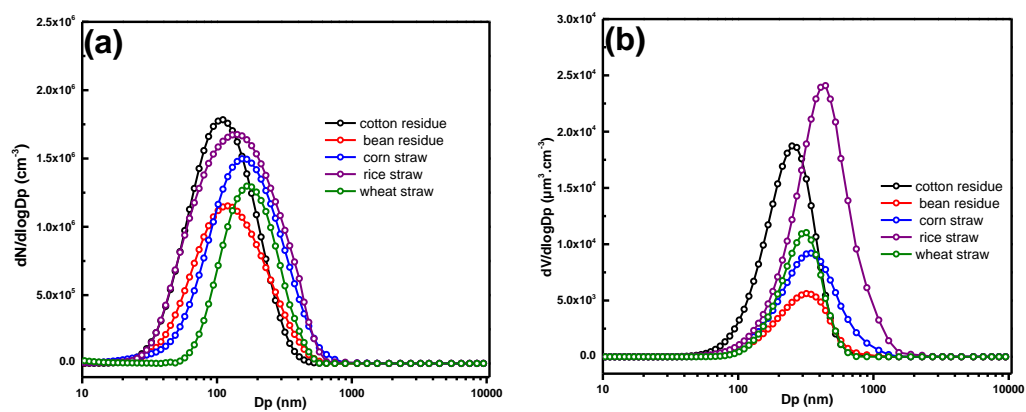


**Fig. S1.** Schematic graph of the aerosol system for agricultural straw open burning and emission characterization.

115

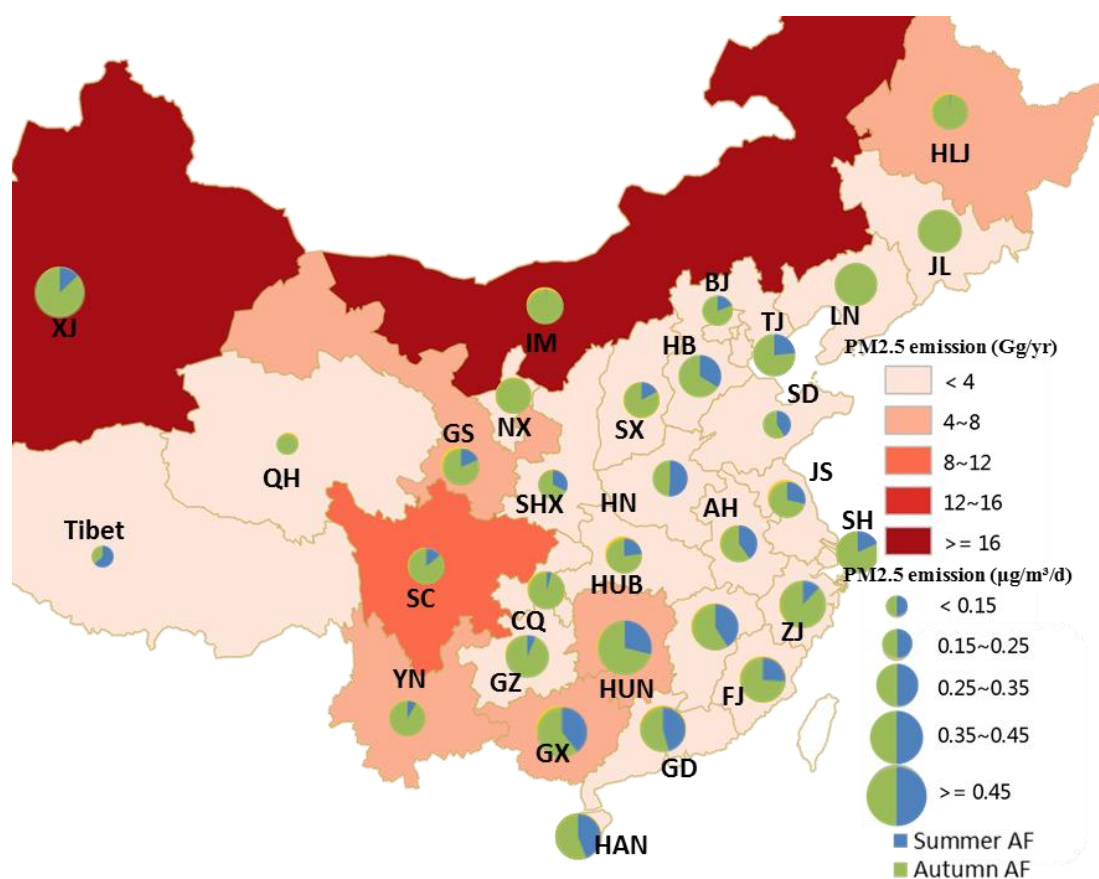


**Fig. S2.** Satellite remote sensing of agricultural fire sites from 2011 to 2013; Average nationwide open burning lasts 114 days annually, 54 days in summer harvest from May to August, 60 days in autumn harvest from September to November. (AF: short of Agricultural Fires).



125 **Figure S3.** Size distribution of smoke particles from agricultural residue burning in term of number concentration and volume concentration.





**Figure S4.** Distribution of smoke PM<sub>2.5</sub> emissions from agricultural straw burning in China under carcinogenic risk control scenarios.

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185