*Supplement of*

# A comprehensive biomass burning emission inventory with high spatial and temporal resolution in China

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# Supporting Information

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S1 The correlation between crop yield and grain yield at prefecture resolution.

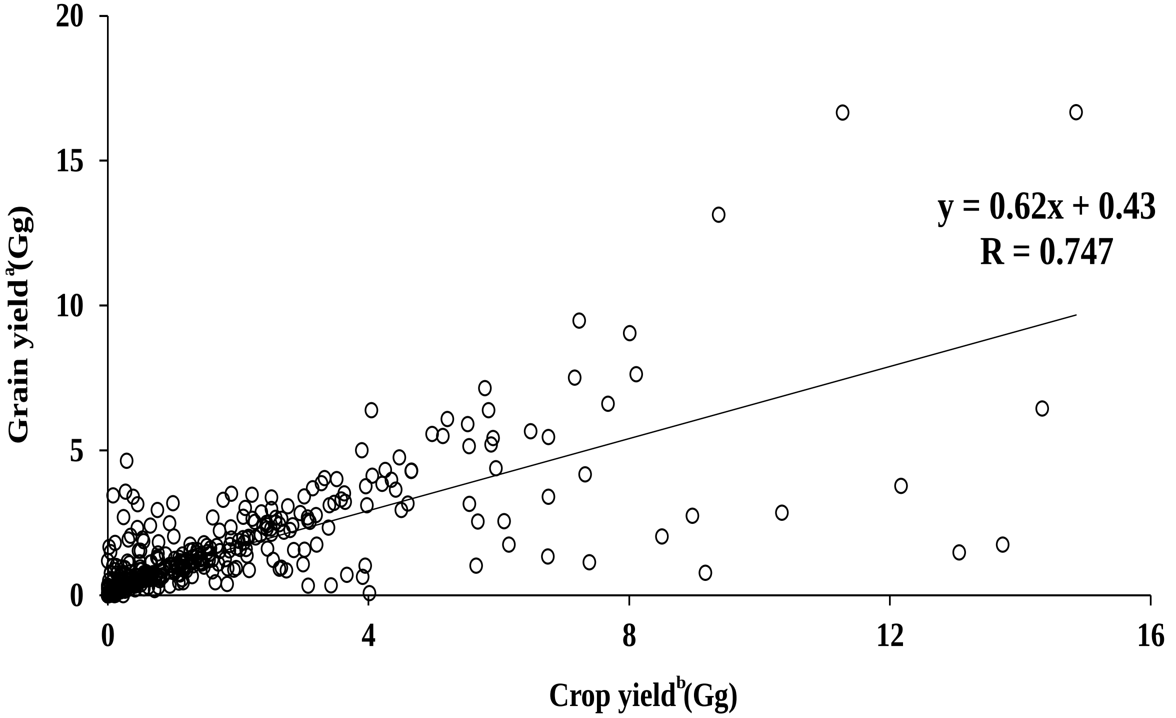


Figure S1 The correlation between crop yield and grain yield at prefecture resolution.[a]

Note: [a] NBSC (2013b); [b] a range of statistical yearbooks edited by National Bureau of Statistics in 2012 for each province.

# S2 Map showing the prefecture and county resolution.

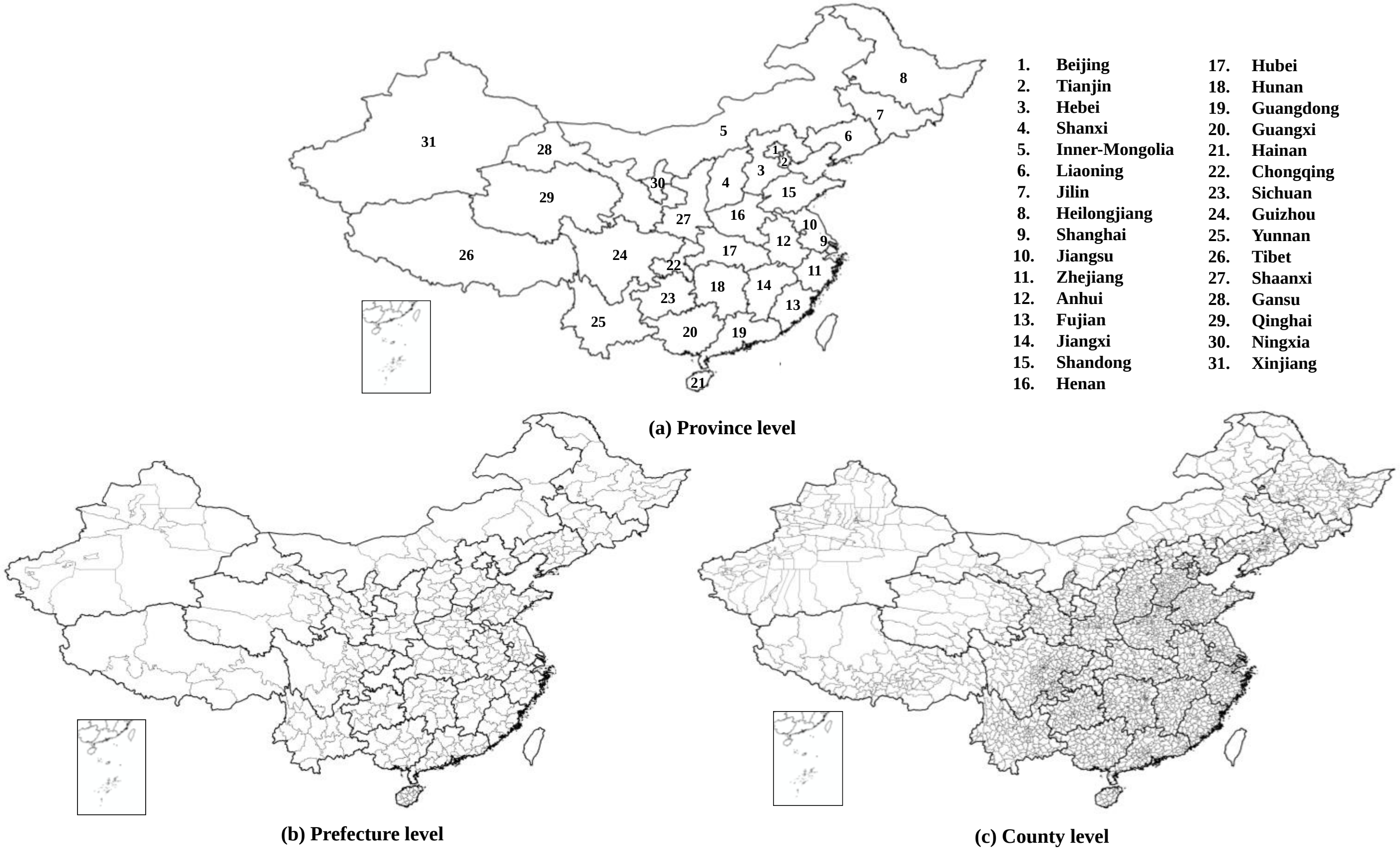


**Figure S2 Map showing the prefecture and county resolution.**

**S3 The details about questionnaire field survey.**

A questionnaire was designed to conduct field investigation during face-to-face interviews with rural resident, in order to obtain the percentage of crop straw indoor burning and outdoor burning and uneven temporal distribution coefficient in several provinces with limited literature reports, including Tianjin, Hebei, Inner Mongolia, Heilongjiang, Shanghai, Zhejiang, Anhui, Jiangxi and Guangdong provinces. Respondents need to provide the detailed address, main cultivated crop type. They selected from a list of cooking and heating fuels, including specific crop straw, firewood, coal, gas, electricity or solar, livestock excrement and other detailed fuels not existing in the list. They also need to provide approximate proportion of crop straw domestic combustion and in field burning, and selected the month of burning the straw as waste, and heating period. The investigation was launch in the representative regions in each province mentioned above, with the integrative consideration about the geographical location, economic development level and population intensity. All the surveyors were trained and tested in their understanding of the questionnaire content. Ultimately, we received 2478 valid questionnaire responses, and at least 200 valid questionnaires in each province.

## S4 The detailed description about the MODIS fire data and calculation method and equation of gridded emission

### 4.1 Detailed description about the MODIS fire data

For the spatiotemporal distributions of biomass open burning, satellite remote sensing has excellent characteristics of wide coverage, high resolution and strong temporal reliability. As a result, satellite remote sensing has been increasingly applied to solving temporal and spatial emission distributions in recent years. The MODIS satellite fire data were taken from FIRM (Fire Information for Resource Management System). The MODIS Thermal Anomalies/Fire 5-Min L2 Swath Product (MOD14/MYD14) within 1km resolution was used in this study. The MOD14 were provided by the Terra satellite with overpass times at 10:30 AM and 10:30 PM local time, while MYD14 were provided by Aqua at 1:30 AM and 1:30 PM local time.

### 4.2 Detailed calculation method and equation of gridded emission

The mass of biomass emission in each grid of biomass open burning and indoor burning was calculated using Eqs. (1) and (2), respectively, as follows:

$$E_{m-outdoor} = \frac{FC_m}{FC_n} \times E_{n-outdoor} \tag{1}$$

$$E_{m-indoor} = \frac{PO_m}{PO_n} \times E_{n-indoor} \tag{2}$$

where *m* is the *m*-th grid and *n* represents the *n*-th county; $E_{m\text{-}outdoor}$ and $E_{n\text{-}outdoor}$ represent the emissions of the *m*-th grid and *n*-th county for biomass outdoor burning (in-field crop residue burning), respectively; $E_{m\text{-}indoor}$ and $E_{n\text{-}indoor}$ represent the emissions of the *m*-th grid and *n*-th county for biomass indoor burning, respectively; $FC_m$ represents the number of typical fire points of the *m*-th grid; $FC_n$ is the number of total typical fire points of the *n*-th county; $PO_m$ is the number of typical population of the *m*-th grid; finally, $PO_n$ is the number of typical population of the *n*-th county.

**S5 Daily $PM_{2.5}$ biomass burning emissions variation in 2012.**

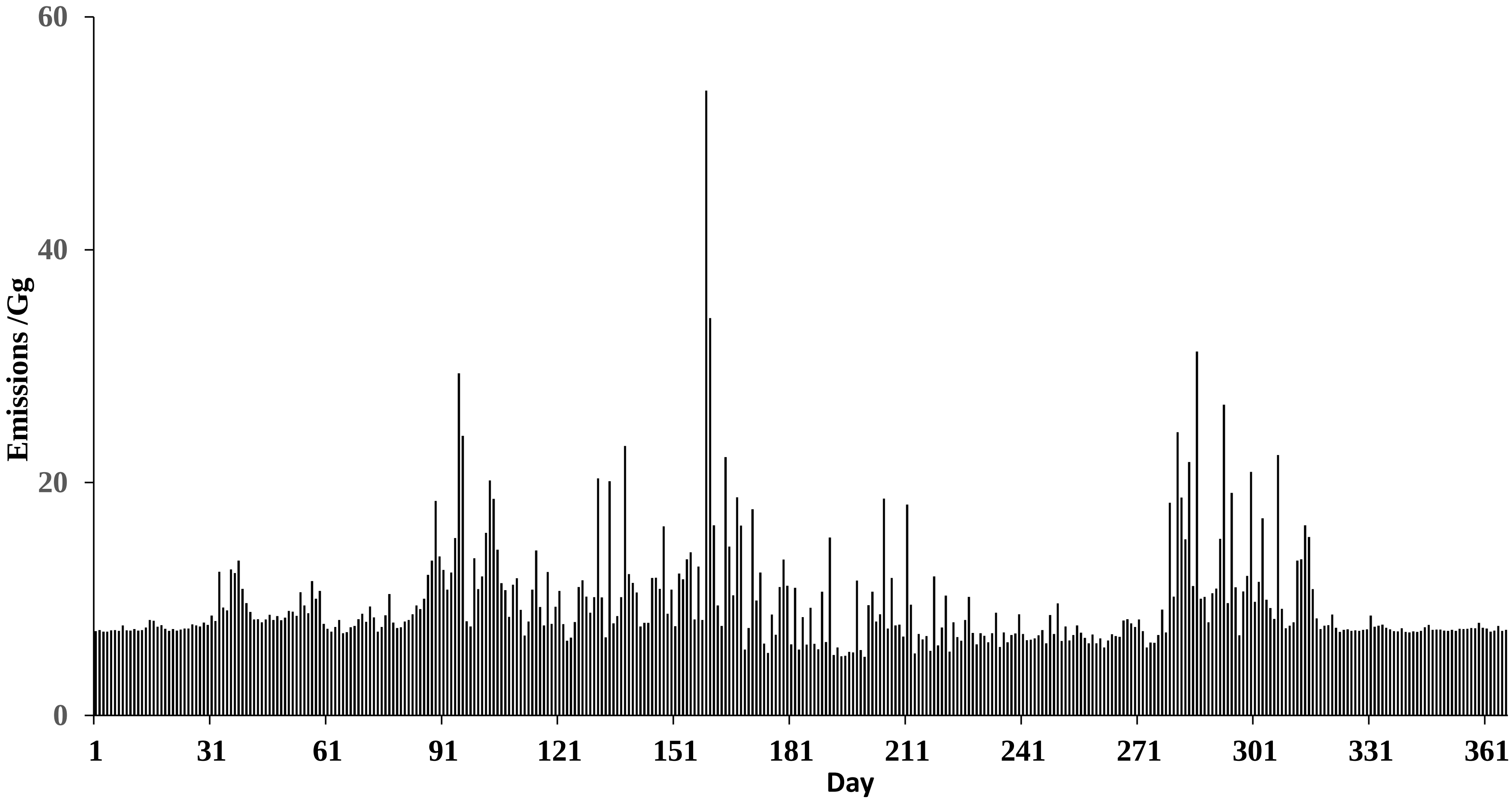


**Figure S3 Daily $PM_{2.5}$ biomass burning emissions variation in 2012.**

## S6 Emission of PM2.5 species from biomass burning

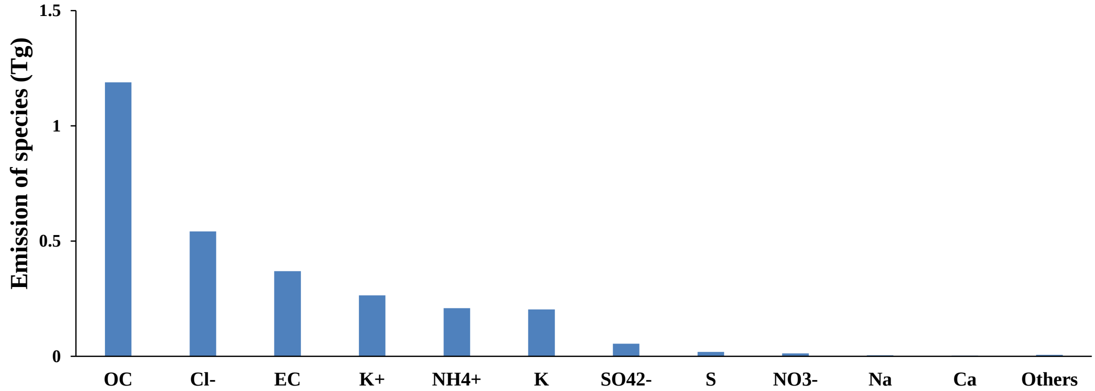


**Figure S4 Emission of $PM_{2.5}$ species from biomass burning.**

Note: Species in others include Al，Si，Mg，Fe，Pb，Zn，Ba，Ti，Ni，Cr，Mn，Sr，V，Cd，As，Zr，Se，Ag，Sb，Sc，Mo，Ga，Tl，Co and Hg. $PM_{2.5}$ speciation profile is obtained from Li et al., (2007) and Waston et al., (2001).

## S7 Emission of NMVOCs species from biomass burning.

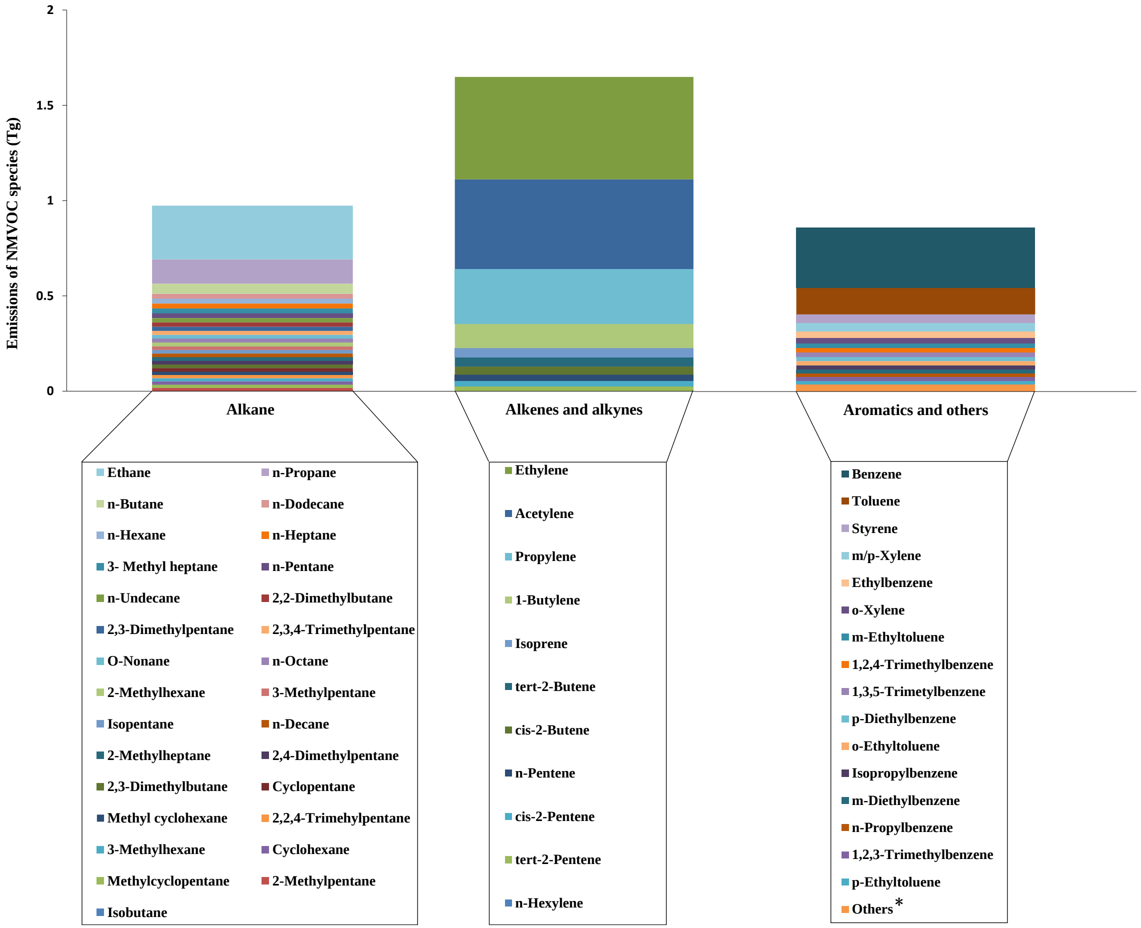


**Figure S5 Emission of NMVOC species from biomass burning.**

Note: *Species in others include aldehyde, ethers, alcohols, esters, ketone and acids. ~~**Figure S5 Emission of VOCs species from biomass burning.**~~

## S8 CV (coefficients of variation) of biomass domestic burning emission factors.

| | Material | $SO_2$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | NMVOC | $NH_3$ | CO | EC | OC | $CO_2$ | $CH_4$ | Hg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Domestic burning | Corn | 0.5[*] | 0.02[a] | 0.5[*] | 0.27[b] | 0.5[*] | 0.5[*] | 0.85[a] | 0.34[b] | 0.44[b] | 0.04[a] | 0.5[*] | 0.05[c] |
| | Wheat | 0.5[*] | 0.16[a] | 0.5[*] | 0.23[b] | 0.5[*] | 0.5[*] | 0.89[a] | 0.76[b] | 0.29[b] | 0.07[a] | 0.5[*] | 0.12[c] |
| | Cotton | 0.5[*] | 0.5[*] | 0.5[*] | 0.26[b] | 0.5[*] | 0.5[*] | 0.5[*] | 0.39[b] | 0.55[b] | 0.5[*] | 0.5[*] | 0.33[c] |
| | Cane | 0.5[*] | 0.5[*] | 0.5[*] | 0.26[b] | 0.5[*] | 0.5[*] | 0.5[*] | 0.63[b] | 0.45[b] | 0.5[*] | 0.5[*] | 0.32[c] |
| | Potato | 0.5[*] | 0.5[*] | 0.5[*] | 0.26[b] | 0.5[*] | 0.5[*] | 0.5[*] | 0.63[b] | 0.45[b] | 0.5[*] | 0.5[*] | 0.53[c] |
| | Peanut | 0.5[*] | 0.5[*] | 0.5[*] | 0.26[b] | 0.5[*] | 0.5[*] | 0.5[*] | 0.63[b] | 0.45[b] | 0.5[*] | 0.5[*] | 0.03[c] |
| | Rape | 0.5[*] | 1.21[d] | 0.5[*] | 0.15[b] | 0.26[d] | 0.5[*] | 0.26[d] | 0.63[b] | 0.45[b] | 0.5[*] | 0.5[*] | 0.3[c] |
| | Sesame | 0.5[*] | 1.78[d] | 0.5[*] | 0.26[b] | 0.24[d] | 0.5[*] | 0.29[d] | 0.63[b] | 0.45[b] | 0.5[*] | 0.5[*] | 0.3[c] |
| | Beet | 0.5[*] | 0.5[*] | 0.5[*] | 0.26[b] | 0.5[*] | 0.5[*] | 0.5[*] | 0.63[b] | 0.45[b] | 0.5[*] | 0.5[*] | 0.3[c] |
| | Hemp | 0.5[*] | 0.5[*] | 0.5[*] | 0.26[b] | 0.5[*] | 0.5[*] | 0.5[*] | 0.63[b] | 0.45[b] | 0.5[*] | 0.5[*] | 0.3[c] |
| | Rice | 0.5[*] | 0.05[a] | 0.5[*] | 0.29[b] | 0.5[*] | 0.5[*] | 0.06[a] | 0.65[b] | 0.5[b] | 0.01[a] | 0.5[*] | 0.46[c] |
| | Soybean | 0.5[*] | 1.78[d] | 0.5[*] | 0.26[b] | 0.76[d] | 0.5[*] | 0.44[d] | 0.63[b] | 0.45[b] | 0.5[*] | 0.5[*] | 0.74[c] |
| | Firewood | 0.5[*] | 1.42[d] | 0.5[*] | 0.16[b] | 0.15[d] | 0.5[*] | 0.39[d] | 0.46[b] | 0.35[b] | 0.5[*] | 0.5[*] | 1.17[c] |
| | Feces | 0.8[*] | 0.8[*] | 0.8[*] | 0.8[*] | 0.8[*] | 0.8[*] | 0.8[*] | 0.8[*] | 0.8[*] | 0.8[*] | 0.8[*] | 0.8[*] |

**Table S1 CV (coefficients of variation) of biomass domestic burning emission factors.**

Note: Lowercase letters indicate the data source.

Sources are from the following: [a] Zhang et al. (2008). [b] Li et al. (2009). [c] Chen et al. (2013). [d] Zhang et al. (2013). * Expert judgment data from Wei et al. (2011).

## S9 CV (coefficients of variation) of biomass open burning emission factors

| | Material | $SO_2$ | $NO_x$ | $PM_{10}$ | $PM_{2.5}$ | NMVOC | $NH_3$ | CO | EC | OC | $CO_2$ | $CH_4$ | Hg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Open burning | Corn | 0.45[b] | 0.42[b] | 0.5[*] | 0.09[b] | 0.53[b] | 0.76[b] | 0.08[b] | 0.33[b] | 0.39[b] | 0.01[b] | 0.22[b] | 0.05[a] |
| | Wheat | 0.67[b] | 0.52[b] | 0.5[*] | 0.54[b] | 0.25[b] | 0.38[b] | 0.41[b] | 0.32[b] | 0.26[b] | 0.03[b] | 0.25[b] | 0.12[a] |
| | Cotton | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.33[a] |
| | Cane | 0.5[*] | 0.32[d] | 0.19[d] | 0.16[d] | 0.71[d] | 0.5[*] | 0.61[d] | 1.57[d] | 0.2[d] | 0.18[d] | 0.5[*] | 0.32[a] |
| | Potato | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.53[a] |
| | Peanut | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.03[a] |
| | Rape | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.3[a] |
| | Sesame | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.3[a] |
| | Beet | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.3[a] |
| | Hemp | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.3[a] |
| | Rice | 0.5[*] | 0.8[d] | 0.88[d] | 0.17[d] | 0.75[d] | 0.5[*] | 1.19[d] | 1.38[d] | 1.53[d] | 0.14[d] | 0.5[*] | 0.46[a] |
| | Soybean | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.5[*] | 0.74[a] |
| | Evergreen Needleleaf Forest | 0.3[c] | 0.39[c] | 0.25[d] | 0.25[d] | 0.31[e] | 0.66[e] | 0.38[e] | 1[f] | 0.62[f] | 0.08[e] | 0.52[e] | 0.52[g] |
| | Evergreen Broadleaf Forest | 0.4[e] | 0.54[e] | 0.25[d] | 0.25[d] | - | 1.58[h] | 0.29[e] | 0.6[e] | 0.57[e] | 0.04[e] | 0.39[e] | 0.52[g] |
| | Deciduous Needleleaf Forest | 0.3[c] | 0.23[c] | 0.25[d] | 0.25[d] | 0.31[e] | 0.66[e] | 0.38[r] | 1[f] | 0.62[f] | 0.08[e] | 0.52[r] | 0.52[g] |
| | Deciduous Broadleaf Forest | 0.3[c] | 0.46[e] | 0.25[d] | 0.25[d] | 0.79[e] | 0.27[e] | 0.19[e] | 0.33[e] | 0.52[e] | 0.02[e] | 0.18[e] | 0.52[g] |
| | Mixed Forest | 0.3[c] | 0.46[e] | 0.25[d] | 0.25[d] | 0.62[e] | 0.27[e] | 0.19[e] | 0.33[e] | 0.52[e] | 0.02[e] | 0.18[e] | 0.52[g] |
| | Closed Shrublands | 0.44[e] | 0.21[e] | 0.25[d] | 0.25[d] | 0.48[e] | 0.33[e] | 0.25[e] | 0.4[f] | 0.18[f] | 0.02[e] | 0.35[e] | 0.74[h,g] |
| | Open Shrublands | 0.44[e] | 0.21[e] | 0.25[d] | 0.25[d] | 0.48[e] | 0.33[e] | 0.25[e] | 0.4[f] | 0.18[f] | 0.02[e] | 0.35[e] | 0.74[h,g] |
| | Woody Savannas | 0.44[e] | 0.21[e] | 0.25[d] | 0.25[d] | 0.48[e] | 0.33[e] | 0.25[e] | 0.4[f] | 0.18[f] | 0.02[e] | 0.35[e] | 0.52[h] |
| | Savannas | 0.63[e] | 0.29[e] | 0.25[d] | 0.25[d] | 0.25[e] | 0.8[e] | 0.29[e] | 0.5[e] | 0.46[e] | 0.02[e] | 0.6[e] | 0.52[h] |
| | Grasslands | 0.63[e] | 0.29[e] | 0.25[d] | 0.25[d] | 0.25[e] | 0.8[e] | 0.29[e] | 0.5[e] | 0.46[e] | 0.02[e] | 0.6[e] | 0.52[h] |

**Table S2 CV (coefficients of variation) of biomass open burning emission factors**

Note: Lowercase letters indicate the data source.

Sources are from the following: [a] Chen et al. (2013). [b] Li et al. (2007). [c] Andreae and Rosenfeld (2008). [d] Song et al. (2009). [e] Akagi et al. (2011). [f] McMeekin et al. (2008). [g] Friedli et al. (2003). [h] Streets et al. (2005). * Expert judgment data from Wei et al. (2011).

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