Supplement of

Impact of crop field burning and mountains on heavy haze in the North China Plain: a case study

Xin Long et al.

Correspondence to: X. X. Tie (xxtie@urcar.edu) and R. J. Huang (rujin.huang@ieecas.cn)

The copyright of individual parts of the supplement might differ from the CC-BY 3.0 licence.
Table S1 National and provincial estimated amounts of crop production ($P_{i,k}$), CFB proportion ($F_i$), CO emission and CFB activities times ($FC_i$) in China in 2014.

<table>
<thead>
<tr>
<th>Province</th>
<th>$P_{i,k}^a$ (Gg)</th>
<th>Rice</th>
<th>Corn</th>
<th>Wheat</th>
<th>$F_i^b$ (%)</th>
<th>CO Emission (Mg)</th>
<th>$FC_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>1</td>
<td>500</td>
<td>122</td>
<td>18.65</td>
<td>6.1</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>Tianjin</td>
<td>121</td>
<td>1014</td>
<td>586</td>
<td>20.75</td>
<td>22.5</td>
<td>308</td>
<td></td>
</tr>
<tr>
<td>Hebei</td>
<td>542</td>
<td>16707</td>
<td>14299</td>
<td>18.80</td>
<td>392.0</td>
<td>2222</td>
<td></td>
</tr>
<tr>
<td>Shanxi</td>
<td>6</td>
<td>9381</td>
<td>2591</td>
<td>17.50</td>
<td>111.9</td>
<td>974</td>
<td></td>
</tr>
<tr>
<td>Inner Mongolia</td>
<td>524</td>
<td>21861</td>
<td>1539</td>
<td>13.70</td>
<td>153.4</td>
<td>1868</td>
<td></td>
</tr>
<tr>
<td>Liaoning</td>
<td>4515</td>
<td>11705</td>
<td>28</td>
<td>16.70</td>
<td>152.7</td>
<td>2761</td>
<td></td>
</tr>
<tr>
<td>Jilin</td>
<td>5876</td>
<td>27335</td>
<td>1</td>
<td>15.00</td>
<td>255.2</td>
<td>2976</td>
<td></td>
</tr>
<tr>
<td>Heilongjiang</td>
<td>22510</td>
<td>33434</td>
<td>466</td>
<td>12.60</td>
<td>445.0</td>
<td>6603</td>
<td></td>
</tr>
<tr>
<td>Shanghai</td>
<td>841</td>
<td>26</td>
<td>186</td>
<td>27.70</td>
<td>26.5</td>
<td>201</td>
<td></td>
</tr>
<tr>
<td>Jiangsu</td>
<td>19120</td>
<td>2390</td>
<td>11604</td>
<td>33.05</td>
<td>969.6</td>
<td>2453</td>
<td></td>
</tr>
<tr>
<td>Zhejiang</td>
<td>5901</td>
<td>301</td>
<td>310</td>
<td>24.40</td>
<td>142.4</td>
<td>1278</td>
<td></td>
</tr>
<tr>
<td>Anhui</td>
<td>13946</td>
<td>4655</td>
<td>13936</td>
<td>28.40</td>
<td>786.9</td>
<td>5240</td>
<td></td>
</tr>
<tr>
<td>Fujian</td>
<td>4971</td>
<td>203</td>
<td>7</td>
<td>28.45</td>
<td>132.6</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td>Jiangxi</td>
<td>20252</td>
<td>123</td>
<td>26</td>
<td>14.10</td>
<td>263.4</td>
<td>781</td>
<td></td>
</tr>
<tr>
<td>Shandong</td>
<td>1010</td>
<td>19883</td>
<td>22638</td>
<td>22.25</td>
<td>675.5</td>
<td>4152</td>
<td></td>
</tr>
<tr>
<td>Henan</td>
<td>5286</td>
<td>17321</td>
<td>33290</td>
<td>21.10</td>
<td>908.9</td>
<td>4725</td>
<td></td>
</tr>
<tr>
<td>Hubei</td>
<td>17295</td>
<td>2937</td>
<td>4216</td>
<td>17.65</td>
<td>371.5</td>
<td>1541</td>
<td></td>
</tr>
<tr>
<td>Hunan</td>
<td>26340</td>
<td>1886</td>
<td>103</td>
<td>28.75</td>
<td>721.5</td>
<td>716</td>
<td></td>
</tr>
<tr>
<td>Guangdong</td>
<td>10916</td>
<td>769</td>
<td>3</td>
<td>31.60</td>
<td>327.3</td>
<td>768</td>
<td></td>
</tr>
<tr>
<td>Guangxi</td>
<td>11661</td>
<td>2664</td>
<td>2</td>
<td>23.95</td>
<td>283.7</td>
<td>224</td>
<td></td>
</tr>
<tr>
<td>Hainan</td>
<td>1554</td>
<td></td>
<td></td>
<td>21.45</td>
<td>30.6</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Chongqing</td>
<td>5032</td>
<td>2560</td>
<td>270</td>
<td>14.85</td>
<td>88.5</td>
<td>434</td>
<td></td>
</tr>
<tr>
<td>Sichuan</td>
<td>15265</td>
<td>7519</td>
<td>4232</td>
<td>15.35</td>
<td>324.5</td>
<td>1108</td>
<td></td>
</tr>
<tr>
<td>Guizhou</td>
<td>4032</td>
<td>3138</td>
<td>615</td>
<td>13.25</td>
<td>74.3</td>
<td>348</td>
<td></td>
</tr>
<tr>
<td>Yunnan</td>
<td>6661</td>
<td>7433</td>
<td>836</td>
<td>12.85</td>
<td>129.2</td>
<td>391</td>
<td></td>
</tr>
<tr>
<td>Tibet</td>
<td>5</td>
<td>24</td>
<td>237</td>
<td>12.30</td>
<td>2.9</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Shaanxi</td>
<td>909</td>
<td>5396</td>
<td>4172</td>
<td>17.15</td>
<td>120.0</td>
<td>626</td>
<td></td>
</tr>
<tr>
<td>Gansu</td>
<td>35</td>
<td>5645</td>
<td>2716</td>
<td>13.70</td>
<td>67.8</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>Qinghai</td>
<td>0</td>
<td>187</td>
<td>349</td>
<td>12.55</td>
<td>5.1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Ningxia</td>
<td>618</td>
<td>2241</td>
<td>406</td>
<td>16.25</td>
<td>30.8</td>
<td>192</td>
<td></td>
</tr>
<tr>
<td>Xinjiang</td>
<td>762</td>
<td>6411</td>
<td>6423</td>
<td>16.15</td>
<td>151.5</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>206507</strong></td>
<td><strong>215649</strong></td>
<td><strong>126209</strong></td>
<td></td>
<td><strong>8174</strong></td>
<td><strong>43754</strong></td>
<td></td>
</tr>
</tbody>
</table>

a. The values were taken from NBS (2015). b. The values were taken from Wang and Zhang (2008) and Zhang Yisheng (Unpublished doctor thesis-in Chinese). Parameters $P_{i,k}$ and $F_i$ are related to Equation 1 and $FC_i$ is related to Equation 2 in the text.
Table S2. Parameters used in the calculation of the amount of CFB.

<table>
<thead>
<tr>
<th>species</th>
<th>residue-to-crop ratio (^a) ( (R_k) )</th>
<th>dry residue fraction (^b) ( (D_k) )</th>
<th>combustion efficiency (^b) ( (CE_k) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>rice</td>
<td>1.00</td>
<td>0.89</td>
<td>0.93</td>
</tr>
<tr>
<td>corn</td>
<td>1.04</td>
<td>0.40</td>
<td>0.92</td>
</tr>
<tr>
<td>wheat</td>
<td>1.17</td>
<td>0.83</td>
<td>0.86</td>
</tr>
</tbody>
</table>

\(^a\) The values were taken from Xie et al. (2011). \(^b\) The values were taken from Street et al. (2003) and He et al. (2011). Parameters R, D, and E are related to Equation 4 in the text.
## Table S3. Summary of CO EFs from CFB reported in the literature (g kg⁻¹).

<table>
<thead>
<tr>
<th>Location</th>
<th>Residue type</th>
<th>Measurement approach</th>
<th>CO EF (g kg⁻¹)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>China</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>crop residue</td>
<td>chamber</td>
<td>52.0±18.9</td>
<td>Ni et al. (2015)</td>
</tr>
<tr>
<td></td>
<td>Rice straw</td>
<td>tower</td>
<td>53.2±17.9</td>
<td>Zhang et al. (2013)</td>
</tr>
<tr>
<td></td>
<td>Rice straw</td>
<td>tower</td>
<td>110.6±37.9</td>
<td>Zhang et al. (2013)</td>
</tr>
<tr>
<td></td>
<td>rice straw</td>
<td>chamber</td>
<td>87.1±30.3</td>
<td>McMeeking et al. (2009)</td>
</tr>
<tr>
<td></td>
<td>corn stalk</td>
<td>chamber</td>
<td>114.7±12.4</td>
<td>Zhang et al. (2008)</td>
</tr>
<tr>
<td></td>
<td>wheat straw</td>
<td>chamber</td>
<td>141.2±14.8</td>
<td>Zhang et al. (2008)</td>
</tr>
<tr>
<td></td>
<td>rice straw</td>
<td>chamber</td>
<td>64.2±4.9</td>
<td>Zhang et al. (2008)</td>
</tr>
<tr>
<td></td>
<td>wheat straw</td>
<td>field measurement</td>
<td>60±23</td>
<td>Li et al. (2007)</td>
</tr>
<tr>
<td></td>
<td>corn stalk</td>
<td>field measurement</td>
<td>53±4.0</td>
<td>Li et al. (2007)</td>
</tr>
<tr>
<td><strong>Asia else</strong></td>
<td>wheat straw</td>
<td>field measurement</td>
<td>28±20</td>
<td>Sahai et al. (2007)</td>
</tr>
<tr>
<td>India</td>
<td>rice straw</td>
<td>field measurement</td>
<td>97±8</td>
<td>Kim Oanh et al. (2011)</td>
</tr>
<tr>
<td>Thailand</td>
<td>rice straw</td>
<td>chamber</td>
<td>179.9±39.8</td>
<td>Christian et al. (2003)</td>
</tr>
<tr>
<td>Indonesia</td>
<td>rice straw</td>
<td>field measurement</td>
<td>104±4</td>
<td>Nguyen et al. (1994)</td>
</tr>
<tr>
<td>Vietnam</td>
<td>rice straw</td>
<td>field measurement</td>
<td>189±2</td>
<td>Nguyen et al. (1994)</td>
</tr>
<tr>
<td>Japan</td>
<td>wheat straw</td>
<td>chamber</td>
<td>42±2</td>
<td>Hayashi et al. (2014)</td>
</tr>
<tr>
<td>Japan</td>
<td>wheat straw</td>
<td>chamber</td>
<td>77±3</td>
<td>Hayashi et al. (2014)</td>
</tr>
<tr>
<td>Japan</td>
<td>rice straw</td>
<td>chamber</td>
<td>27±4</td>
<td>Hayashi et al. (2014)</td>
</tr>
<tr>
<td>Japan</td>
<td>rice straw</td>
<td>chamber</td>
<td>59±4</td>
<td>Hayashi et al. (2014)</td>
</tr>
<tr>
<td>Japan</td>
<td>rice straw</td>
<td>chamber</td>
<td>44±4</td>
<td>Miura and Kanno (1997)</td>
</tr>
<tr>
<td>Japan</td>
<td>rice straw</td>
<td>chamber</td>
<td>70±4</td>
<td>Miura and Kanno (1997)</td>
</tr>
<tr>
<td><strong>USA</strong></td>
<td>wheat straw</td>
<td>field measurement</td>
<td>26–64</td>
<td>Air Sciences Inc. (2003)</td>
</tr>
<tr>
<td>USA</td>
<td>wheat straw</td>
<td></td>
<td>54±4</td>
<td>U.S.EPA. (1995)</td>
</tr>
<tr>
<td>USA</td>
<td>rice straw</td>
<td>wind tunnel</td>
<td>32.2±10</td>
<td>Jenkins et al. (1998)</td>
</tr>
<tr>
<td>USA</td>
<td>rice straw</td>
<td></td>
<td>41±4</td>
<td>U.S.EPA. (1995)</td>
</tr>
<tr>
<td>Mexico</td>
<td>crop residue</td>
<td>airborne measurements</td>
<td>85.56±33.75</td>
<td>Yokelson et al. (2011)</td>
</tr>
<tr>
<td>Mexico</td>
<td>agricultural residues</td>
<td>airborne measurements</td>
<td>92±4</td>
<td>Andreae and Merlet. (2001)</td>
</tr>
</tbody>
</table>
References:


Nguyen, B., Putaud, J., Mihalopoulos, N., Bonsang, B., Doan, C., 1994. CH$_4$ and CO emissions
from rice straw burning in South East Asia. Environmental Monitoring and Assessment 31, 131-137.


Fig. S1 Crop field burning captured by MODIS along with the background of MODIS real-time true color map from Oct. 6th to 11th.
Fig. S2 The sensitivity experiments to mountain effects, including (a) the enclosing scope and sensitive configuration of remove behaviors for (b) both mountains of Taihang and Yanshan (R-TY), (c) Taihang Mountains (R-T) and (d) Yanshan Mountains (R-Y).
Fig. S3 The schematic pictures of mountains effect along with the topography of the NCP region. (a) Mountains block the airflows and cause pollutants accumulated at the foothill of mountains (Influence-2, block). (b) Mountains redirect the airflows, and cause pollutants move toward the downwind foothill areas (Influence-2, redirect). The 200-meter contour was highlighted with bold black line.