Black carbon emission factors and size distribution from biomass burning in California

Taylor, Jonathan W.1, McMeeking, Gavin R.1, Craven, Jill2, Yokelson, Robert3, Akagi, Sheryl3, Urbanski, Shawn4, Wold, Cyle4, Flynn, Michael4, Seinfeld, John2 and Coe, Hugh1

1Centre for Atmospheric Science, School of Earth, Atmospheric and Environmental Sciences, University of Manchester, M13 9PL, UK
2Department of Chemical Engineering, California Institute of Technology, Pasadena, CA 91125, USA
3Department of Chemistry, University of Montana, Missoula, MT 59812, USA
4United States Forest Service Fire Sciences Laboratory, Missoula, MT 59808, USA

1. The SLOBB Campaign

The SLOBB (San Luis Obispo Biomass Burning experiment) campaign took place in central California, USA in November 2009. The aim of the project was to assess the impact of prescribed burns on air quality using airborne smoke samplers. 6 fires were sampled in total, at locations shown in Figure 1. This analysis refers to a single fire, known as the Williams Fire, burning chemise, shown in Figure 2 and highlighted in Figure 1.

2. Instrumentation

The Droplet Measurement Technologies Single Particle Soot Photometer (SP2, shown in Figure 3) utilizes the principle of light-induced incandescence. A 1064nm Nd:YAG LASER is shone on particles, and scattered light is detected by 2 avalanche photodiode detectors. Absorbing particles vaporise when passing through the beam, and BC heats to incandescence emitting visible light with intensity proportional to the mass of BC.

In addition to the SP2, the aircraft was fitted with an Aerodyne Aerosol Mass Spectrometer (AMS), Aerodyne Fourier-Transform Infrared Spectrometer (AFTIR), LiCor CO monitor and TSI integrating Nephelometer. The fraction of “thickly coated” particles was shown to increase quickly as smoke moved away from the source, as shown in Figure 5. Coating behaviour appeared to take place over timescales of minutes rather than hours, as has been seen previously.

4. BC core mass size distribution

The BC core mass size distribution is shown in Figure 6. The BC cores were ~25% smaller than typical BC size distributions. Further work to determine the conditions affecting BC core size distribution is recommended.

5. Coating growth

Coatings vapourise on the heated BC core, inhibiting incandescence through uptake of latent heat, and thus causing a time delay between the detected scattering and incandescence signals. Particles can be divided into ‘thickly coated’ by the time delay, which shows a bimodal distribution, shown in Figure 7.

6. Conclusions

The fraction of ‘thickly coated’ particles, a qualitative indicator of coatings thickness, was shown to increase quickly as smoke moved away from the source, as shown in Figure 8. This qualitatively indicates an increase in particle coatings. Coating behaviour appeared to take place over timescales of minutes rather than hours, as has been seen previously.

Table 1: Summary of emission ratios compared to literature values. Values in brackets represent one standard deviation.

<table>
<thead>
<tr>
<th></th>
<th>BC/CO</th>
<th>BC/OC</th>
<th>OC/CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLOBB Williams</td>
<td>0.0084(4)</td>
<td>0.180(17)</td>
<td>0.042(2)</td>
</tr>
<tr>
<td>Fire</td>
<td>0.0074</td>
<td>0.14</td>
<td>0.052</td>
</tr>
</tbody>
</table>

References
