Real-time emissions of biomass burning aerosol under controlled conditions

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Particulate emissions from biomass burning are known to impact the climate substantially by affecting the atmosphere's radiative balance. In addition, they can cause significant harm to human health. This is of particular concern in tropical regions, where small-scale residential burning, wildfires and agricultural burning introduce vast quantities of polluting aerosol into the atmosphere (Bond *et al* 2013; Venkataraman *et al* 2005).

Biomass burning emissions in models are typically calculated using emission factors taken from large inventories. These are determined from field observations and laboratory tests using a wide variety of fuels. However, due to the huge variation in emissions associated with even small changes to the burning environment, the uncertainty of these measurements can be large (Akagi *et al* 2011).

Previous studies have considered the relationship between emission factors and the fire-integrated combustion efficiency (eg McMeeking *et al* 2009). The difference between flaming and smouldering combustion is often taken into account, but it has, as yet, not been possible to distinguish greater levels of detail.

In this study, the Fire Propagation Apparatus was used to strictly control the conditions of combustion in comparison with previous experiments. The burning environment was controlled by a series of infrared heat lamps positioned around the sample and the airflow was adjusted to a pre-defined level. Samples were of similar size, mass and quality in each test. Coupling this system with an Aerosol Mass Spectrometer and a Single Particle Soot Photometer, it was possible to measure real-time particulate emissions of West African wood under well-defined, repeatable conditions.

This methodology produced remarkably repeatable results, allowing aerosol emissions to be mapped directly onto different phases of the combustion. Several details emerged that have not been seen previously: due to pre-ignition heating of the sample, emissions from pyrolysis were visible as a distinct phase before flaming was established. In addition, the flame could be split into a black-carbon-dominant flame and an organic-dominant flame during which very little black carbon was seen. This contradicts previous assumptions that all flaming behaviour is dominated by black carbon emissions. Finally, no particulate emissions at all were measured after the flame extinguished, suggesting that the latter stages of the combustion in these tests was dominated by char oxidation rather than smouldering.

These results clearly demonstrate the importance of understanding the coupling between the combustion processes and the emissions in order to provide a more substantial estimate of the resulting emissions.

Using this approach, it has been possible to examine correlations between burning conditions, fire behaviour and aerosol emissions on a fundamental level. Further research would allow the characteristics of different burning states and their associated emissions to be understood more completely. If the conditions under which biomass is burning are known, this approach will allow its emissions to be modelled with more precision than can currently be achieved.

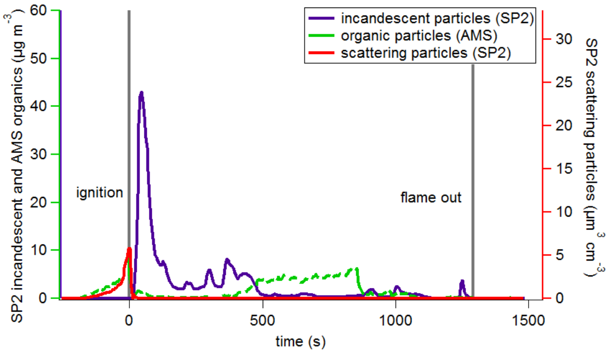

Figure 1. Time series of a burn, showing clear differences in emissions during different phases.

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