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Highly-controlled, reproducible measurements of aerosol emissions from African biomass combustion

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Particulate emissions from biomass burning can alter the atmosphere's radiative balance and cause significant harm to human health. However, the relationship between these emissions and fundamental combustion processes is, to date, poorly characterised. In atmospheric models, aerosol emissions are represented by emission factors based on mass loss, which are averaged over an entire combustion event for each particulate species. This approach, however, masks huge variability in emissions during different phases of the combustion period. Laboratory tests have shown that even small changes to the burning environment can lead to huge variation in observed aerosol emission factors (Akagi et al., 2011).

In order to address this gap in understanding, in this study, small wood samples sourced from Côte D'Ivoire were burned in a highly-controlled laboratory environment. The shape and mass of samples, available airflow and surrounding heat were carefully regulated. Organic aerosol and refractory black carbon emissions were measured in real-time using an Aerosol Mass Spectrometer and a Single Particle Soot Photometer, respectively. Both of these instruments are used regularly to measure aerosol concentrations in the field. This methodology produced remarkably repeatable results, allowing three different phases of combustion to be identified by their emissions. Black carbon was emitted predominantly during flaming combustion; organic aerosols were emitted during pyrolysis before ignition and from smouldering-dominated behaviour near the end of combustion.

During the flaming period, there was a strong correlation between the emission of black carbon and the rate of mass loss, which suggests there is value in employing a mass-based emission factor for this species. However, very little correlation was seen between organic aerosol and mass loss throughout the tests. As such, results here suggest that emission factors averaged over an entire combustion event are unlikely to be useful for organic aerosol emissions. The two different phases producing organic aerosol, pyrolysis and smouldering, were observed to have different mass spectra. In previous ambient experiments, two organic factors with very comparable signatures to these have been identified using positive matrix factorisation (Young et al., 2015). As such, it is postulated that these ambient organic factors are likely associated with the two combustion phases identified here.

References:

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