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The FLAME Deluge: organic aerosol emission ratios from combustion chamber experiments

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A high level of variability has been identified amongst organic aerosol (OA) emission ratios (ER) from biomass burning (BB) under ambient conditions. However, it is difficult to assess the influences of potential drivers for this variability, given the wide range of conditions associated with wildfire measurements. Chamber experiments performed under controlled conditions provide a means of examining the effects of different fuel types and combustion conditions on OA emissions from biomass fuels. ERs have been characterised for 67 burns during the second Fire Laboratory at Missoula Experiment (FLAME II), involving 19 different species from 6 fuel types widely consumed in BB events in the US each year. Average normalised dOA/dCO ratios show a high degree of variability, both between and within different fuel types and species, typically exceeding variability between separate plumes in ambient measurements. Relationships with source conditions were found to be complex, with little consistent influence from fuel properties and combustion conditions for the entire range of experiments. No strong correlation across all fires was observed between dOA/dCO and modified combustion efficiency (MCE), which is used as an indicator of the proportional contributions of flaming and smouldering combustion phases throughout each burn. However, a negative correlation exists between dOA/dCO and MCE for some coniferous species, most notably Douglas fir, for which there is also an apparent influence from fuel moisture content. Significant contrasts were also identified between combustion emissions from different fuel components of additional coniferous species. Changes in fire efficiency were also shown to dramatically alter emissions for fires with very similar initial conditions. Although the relationship with MCE is variable between species, there is greater consistency with the level of oxygenation in OA. The ratio of the m/z 44 fragment to total OA mass concentration (f44) as measured by aerosol mass spectrometer (AMS) provides an indication of oxygenation as influenced by combustion processes at source, with dOA/dCO decreasing with increasing f44 for all fuel types. Inconsistencies in the magnitude of the effects associated with each potential influence on dOA/dCO emphasise the lack of a single dominant control on fire emissions, and a dependency on both fuel properties and combustion conditions.