Determining the effect of temperature and relative humidity on primary and secondary residential wood combustion products

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Residential wood combustion is a significant source of atmospheric aerosols, particularly in winter, as it is a common heating method in regions with moderate and cold climate (Lanz et al., 2010). Nevertheless, uncertainties remain in the magnitude and characteristics of wood burning emissions. Discrepancies exist between the particulate organic mass to black carbon ratio (OM/BC), possibly because previous chamber studies were conducted at higher-than-ambient winter temperatures (Bruns et al., 2015; Gianini, et al., 2012; Grieshop et al., 2009a,b; Heringa et al., 2011). In addition to primary organic aerosol (POA), previous (warm temperature) experiments show that secondary organic aerosol (SOA) formation is significant (Grieshop et al., 2009a,b; Heringa et al., 2011). However, relatively little is known about these secondary aerosols and the role of ambient temperature and relative humidity (RH) in their formation and composition has never been investigated.

We report results from smog chamber experiments characterizing primary and secondary wood combustion products performed for the first time at representative winter temperatures. Experiments were performed at 263 K and 288 K, and at 50% and 90% relative humidity. Primary emissions were diluted to atmospherically-relevant concentrations and injected into the chamber, where OH photochemistry initiated the formation and aging of secondary products. The non-refractory aerosol composition and concentration were determined by aerosol mass spectrometry (AMS) and BC was quantified using Aethalometers. Measurements of gas phase species were made with a suite of instruments, including a proton transfer reaction mass spectrometer (PTR-ToF-MS) and a total hydrocarbon (THC) analyzer.

Primary OM/BC ratios were similar to those observed in previous smog chamber experiments and there was no significant dependence on temperature or relative humidity (Figure 1). With aging, OM/BC ratios increased by up to a factor of ~3 for individual experiments, however the total OM/BC ratios were still lower than most ambient measurements, suggesting that factors besides temperature and relative humidity are the main contributors to discrepancies in OM/BC in the literature.

Upon aging of the emissions, SOA formation was significant in all experiments, with SOA/POA ratios ranging from ~1.5-6.5. The significant SOA formation even at low temperatures with relatively low OH exposure indicates that wood combustion can contribute significantly to SOA formation even in the winter. For example, SOA concentrations were equal to or greater than POA concentrations in all experiments after an OH exposure of only ~1×10^6 molec cm^{-3} h (i.e., one hour of aging at an OH concentration of 1×10^6 molec cm^{-3}).

Primary and aged OM emission factors will be compared for different conditions. Chemical composition data will also be presented.

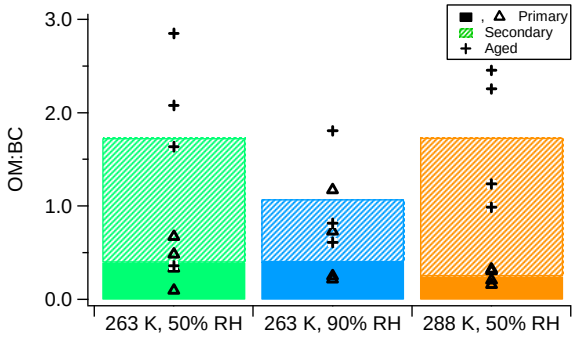

Figure 1. Ratios of organic aerosol mass to black carbon as a function of chamber conditions. Bars are the average of replicates at each condition and markers indicate individual experiments.

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