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The production and characteristics of ice nuclei from biomass burning in the US

Christina S. McCluskey (1), Paul J. DeMott (1), Anthony J. Prenni (1), Gavin R. McMeeking (1,2), Amy P. Sullivan (1), Ezra Levin (1), Shunsuke Nakao (1), Christian M. Carrico (3), Gary D. Franc (4), Thomas C. Hill (4), and Sonia M. Kreidensweis (1)

(1) Department of Atmospheric Science, Colorado State University, Fort Collins, CO, USA, (2) Now at Droplet Measurement Technologies, Boulder, CO, USA, (3) AECOM, Inc., Fort Collins, CO, USA, (4) Department of Plant Sciences, University of Wyoming, Laramie, WY, USA

The production rates and chemical characteristics of heterogeneous ice nuclei (IN) from diverse sources remain largely unknown. Understanding these characteristics is necessary in determining the direct and indirect impacts of aerosols on clouds and the climate. IN emitted from biomass burning are of interest owing to their apparent potential contribution to the global IN reservoir and an anticipated increase in global wildfire frequency that may enhance the role of this source of IN relative to others. Here, we aim to gain insight concerning IN produced from biomass burning through laboratory studies and field measurements of two types of biomass burning: prescribed burning and wildfires.

IN number concentrations at various temperatures were measured with the CSU continuous flow diffusion chamber operated in the condensation/immersion freezing nucleation regime during four large prescribed burns in southwest Georgia and two large wildfires in northern Colorado, USA. Residual IN were captured as activated ice crystals for offline analysis and categorized via transmission electron microscopy based on elemental composition and morphology. Aerosol mass concentrations, total particle number concentrations, aerosol size distribution, and aerosol bulk composition were also measured, as well as carbon monoxide concentrations, used as an indicator of in-plume sampling. Fuel burned during the prescribed burns was a mixture of wiregrass and longleaf pine underbrush, while the wildfire fuels mostly consisted of ponderosa pine underbrush and timber. Specialized measurements were also made in the laboratory incorporating a single particle soot photometer to further investigate the contribution of refractory black carbon to IN produced from combusted wiregrass.

The temporal dependence of IN concentrations at various activation temperatures, relationships between IN and the number concentrations of larger-diameter particles, IN elemental categorizations, and the role of soot particles will be presented. These data provide supporting evidence that biomass burning is a source of IN, and also point to clear differences between the IN produced from prescribed burns and wildfires, likely attributed to differences in fuel type and/or combustion efficiency. The suitability of a previously-developed parameterization for prediction of IN concentrations in smoke aerosol will also be discussed.