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The atmospheric evolution of the ice nucleation properties of biomass burning aerosol

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Biomass burning is a major global source of aerosol emissions. Surprisingly the combustion of some biomass fuels has been found to produce ice nucleating particles that induce immersion freezing at temperatures as warm as –20°C. The source of these ice nucleating particles (INPs) is still under investigation; soot particles do not appear to account for all INPs emitted by biomass burning. We report measurements of efficient INPs in the bottom ash produced from biomass burning. The ash from tall grass fuels that combust rapidly were found to contain a larger fraction of crystalline material through X-ray diffraction analysis, which likely explains the higher ice activity of the ash. Biomass burning can therefore introduce new ice-active mineral phases into the atmosphere, in addition to lofting pre-existing mineral and soil particles that may also act as INPs.

Biomass burning aerosol undergoes extensive physical and chemical transformations during atmospheric transport, and we examined how this evolution might alter the ice nucleation properties of the aerosol. The chemical aging of combustion aerosol from a variety of biomass fuels including sawgrass, birch, cutgrass, and black needlerush was simulated using a smog chamber reactor. Aging such as through dark ozonolysis or UV photolysis of HONO, was often found to enhance the ice activity of the aerosol, observed by an increase in the measured immersion freezing temperature. The chemical composition of the aerosol prior to and following aging was analyzed using two single-particle mass spectrometers (SP-AMS and LAAPTOF), and the particles were collected on filters for SEM/EDX analysis and to determine their ice nucleating abilities. Our novel microfluidic droplet freezing assay allowed us to reliably determine the immersion freezing temperature of the aerosol down to –32°C, critically enabling measurements at lower temperatures where biomass burning aerosol typically induces freezing. We will present our findings on the changes in the aerosol's composition following chemical aging, and how this correlates with the ice nucleating abilities of fresh and aged biomass burning emissions.