Measured and modeled humidification factors of fresh smoke particles from biomass burning: role of inorganic constituents

http://www.firstlight.cn 2010-07-09

During the 2006 FLAME study (Fire Laboratory at Missoula Experiment), laboratory burns of biomass fuels were performed to investigate the physico-chemical, optical, and hygroscopic properties of fresh biomass smoke. As part of the experiment, two nephelometers simultaneously measured dry and humidified light scattering coefficients (bsp(dry) and bsp(RH), respectively) in order to explore the role of relative humidity (RH) on the optical properties of biomass smoke aerosols. Results from burns of several biomass fuels from the west and southeast United States showed large variability in the humidification factor (f(RH)=bsp(RH)/bsp(dry)). Values of f(RH) at RH=80–85% ranged from 0.99 to 1.81 depending on fuel type. We incorporated measured chemical composition and size distribution data to model the smoke hygroscopic growth to investigate the role of inorganic compounds on water uptake for these aerosols. By assuming only inorganic constituents were hygroscopic, we were able to model the water uptake within experimental uncertainty, suggesting that inorganic species were responsible for most of the hygroscopic growth. In addition, humidification factors at 80–85% RH increased for smoke with increasing inorganic salt to carbon ratios. Particle morphology as observed from scanning electron microscopy revealed that samples of hygroscopic particles contained soot chains either internally or externally mixed with inorganic potassium salts, while samples of weak to non-hygroscopic particles were dominated by soot and organic constituents. This study provides further understanding of the compounds responsible for water uptake by young biomass smoke, and is important for accurately assessing the role of smoke in climate change studies and visibility regulatory efforts.

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