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Recent Advances in Modeling the Near-Source Chemistry of Biomass-Burning Plumes in Photochemical Transport Models

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Aerosol and gases freshly emitted from biomass-burning events are a complex mixture of organic species, black carbon, and inorganic salts, with their size, number, and chemical composition dependent on the type of vegetation that is burning, the size and combustion efficiency of the fire event, and the ambient conditions. These mixtures evolve quickly in the atmosphere due to coagulation, evaporation, and chemistry, including trace gases, ozone and secondary organic aerosol formation. Understanding and simulating this complex evolution is critical to assessing and quantifying the impact of biomass-burning plumes on air quality and climate. Since 3D Eulerian models take estimates of the primary emissions from biomass burning and unphysically mix them across large-scale grid boxes, this leads to inaccurate chemical modeling and incorrect estimates of the impact of biomass burning on air quality and climate. Plume-scale process models like the newly developed System for Atmospheric Modeling integrated with AER's Aerosol Simulation Program (SAM-ASP) allow an advanced representation of the near-source biomass-burning plume evolution, with the ability to develop parameterizations for use in air quality and climate models. We present results from a model study of a shrub land fire in California, as well as the development of a parameterization that improves upon the ASP-based parameterization of Lonsdale et al. (2015) that accounted for the formation of trace gases and secondary organic aerosols in biomass burning plumes for various fire conditions and fuel types. The newly improved parameterization additionally includes the complex processes of dispersion, advection, deposition and plume concentrations. We show results of the integration of this parameterization into a plume-in-grid sub-model within a larger-scale photochemical transport model for the first time.