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Using fire radiative power (FRP) observations to describe the vertical transport of wildfire emissions: impacts on atmospheric pollutant transport and inferred flux estimates

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Fires are a large source of trace gases and particles to the atmosphere. The intense surface heating associated with fires can result in rapid convective transport, pyroconvection, which is a sensitive function of local meteorology and surface conditions (e.g., vegetation type). Under certain circumstances, pyroconvection can inject emitted mass out of the boundary layer with implications for its subsequent horizontal transport from the source region. Large uncertainties still exist about how best to describe pyroconvection in large-scale atmospheric transport models. Here, we use satellite observations of fire radiative power (FRP) to determine scene-dependent convective heat flux estimates to help describe pyroconvection. First, we establish a relationship between FRP observations and the corresponding injection height, the maximum altitude reached by the convected mass. Second we include this relationship in a plume rise model that is embedded into the GEOS-Chem global 3-D chemistry transport model (CTM), allowing us to describe processes on spatial scales that are smaller than the CTM model grid scale. GEOS-Chem is used to quantify the impact of FRP-derived injection heights on the atmospheric distribution of carbon monoxide (CO), a tracer of incomplete combustion. Third, we use an ensemble Kalman filter to fit MOPITT CO profile retrievals to the GEOS-Chem model to quantify the impact of FRP-derived injection height on inferred surface flux estimates. Finally, we investigate two modifications to our methodology: 1) a leaky vertical pipe in which convected airmasses are modified by vector winds outside the immediate convective region so that a fraction of the emitted mass is removed from the convection cell at altitudes lower than the ultimate injection height; and 2) including a diurnal cycle for convective heat fluxes.