Wildfire Smoke Observations in the Western U.S. from the Airborne Wyoming Cloud Lidar during the BB-FLUX Project

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The upward Wyoming Cloud Lidar (WCL) was deployed onboard the University of Wyoming King Air (UWKA) research aircraft for the Biomass Burning Flux Measurements of Trace Gases and Aerosols (BB-FLUX) field campaign. This paper first describes the generation of calibrated attenuated backscatter coefficients and aerosol extinction coefficients from the WCL measurements. The retrieved aerosol extinction coefficients at the flight level strongly correlate (correlation coefficient, rr > 0.8) with in situ aerosol concentration and carbon monoxide (CO) concentration, providing a first order estimate for converting WCL extinction coefficients into CO and aerosol concentration within wildfire smoke plumes. The integrated CO column concentrations from the WCL data in non-extinguished profiles also correlate (rr = 0.81) with column measurements by the University of Colorado Airborne Solar Occultation Flux instrument, indicating the validity of WCL-derived extinction coefficients.

We then present the reconstructed vertical structures of 7 plumes from the consecutive WCL extinction cross sections. The vertical structures evident in the fire plume cross sections, supported by in situ measurements, showed that the fire plumes had distinct macrophysical and microphysical properties, which are closely related to the plume transport, fire emission intensity, and thermodynamic structure in the boundary layer. All plumes had an injection layer between 2.8 and 4.0 km above sea level, which is generally below the identified boundary layer top height. Plumes that transported upward out of the boundary layer, such as the Rabbit Foot and Pole Creek fires, formed a higher plume at around 5.5 km. The largest and highest Pole Creek fire plume was transported farthest and sampled by UWKA at 170 km, or 2.3 hours, downwind. It was associated with the warmest, driest, deepest boundary layer and the highest wind speed and turbulence. The Watson Creek fire plume intensified in the afternoon with stronger CO emission and larger smoke plume height than that in the morning, indicating a fire diurnal cycle, but some fire plume did not intensify in the afternoon. There were pockets of relatively large irregular aerosol particles at the tops of plumes from active fires. In less active fire plumes, the WCL depolarization ratio and The Passive Cavity Aerosol Spectrometer Probe **(**PCASP) mass mean diameter maximized rather low in the plume.