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Evidence of secondary organic aerosols formation by non-methane hydrocarbons condensation in cold Pyro-cumulonimbus (pyroCb) outflows

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Particle and trace gas emissions can undergo rapid changes in the atmosphere as a result of evaporation, condensation, and coagulation processes that are driven by dynamics and photochemistry. Here we analyze the fate of non-methane hydrocarbons (NMHCs) gases emitted by intense fires associated with pyroCbs towers that rise and cool rapidly and undergo relatively little dilution as they loft smoke into the upper troposphere and lower stratosphere. We use airborne observations of plumes from the Williams Flats Fire over the continental United States taken during 2019 FIREX-AQ campaign. Trace gas data from both fresh boundary smoke and PyroCb-lofted smoke from this fire are compared to that from smoke plumes that stayed at lower altitudes to constrain the roles of condensation, cloud processing and photochemistry in the outflow of pyroCbs. In the pyroCb outflows we observe lower CO normalized NMHCs mixing ratios with low vapor pressure compared to the boundary layer samples while for high vapor pressure compounds there is little difference between the CO normalized NMHC mixing ratios observed in the different fresh smoke plumes. Associated with this decrease in condensable NMHCs we find an increase in particle concentrations, specifically at large sizes (~350nm). These multiple observational facts are used to estimate the secondary organic aerosol production by NMHC condensation in pyroCb. Further analysis of FIREX-AQ data will be used to elucidate the roles of solubility and photochemistry on SOA formation in pyroCbs. These FIREX-AQ results will be used to inform cloud resolving large eddy simulation (LES, HIGRAD) to examine deep convective fire impacts on long range smoke impacts on climate and air quality.