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In situ trace gas and isotopic composition observations of wildfire smoke in the arctic stratosphere

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Wildfires emit a large quantity of aerosols and trace gases, which occasionally reach the lower stratosphere. In August 2017, a pyrocumulonimbus (pyroCB) event injected a large amount of smoke into the stratosphere, observed by lidar and satellites. Satellite observations are in general the main method of detecting these events since in situ aircraft-based measurements of the greenhouse gas composition and related tracers in these plumes at higher altitudes are sparsely made. This work presents balloon-borne trace gas observations of the biomass burning plume in the lower stratosphere, identified by enhanced CO mole fractions. In addition, CO_2 and CH_4 mole fractions as well as isotopic composition of CO (^{13}CO and C^{18}O) have been measured from AirCore and a LIghtweight Stratospheric Air (LISA) sampler flown on a weather balloon from Sodankylä (67.37° N, 26.63° E, 179 m.a.s.l), Finland. We found that the greenhouse gas enhancement ratios (ΔCO:ΔCO_2) and the source signature based on ^{13}CO and C^{18}O independently identify biomass burning as the source of the stratospheric CO enhancement. Back trajectory analysis, performed piecewise using the Chemical Lagrangian Model of the Stratosphere (CLaMS), corrected by the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) backscatter data, trace the plume's origin to the wildfire in British Colombia with an injection date on 12 August 2017. The plume age of 24 days allowed us to estimate the original CO mole fractions and the enhancement ratios of CO to CO_2 after the corrections due to its chemical loss is applied. The in situ observations provide valuable information on the trace gas chemistry of smoke plumes that reach the stratosphere, as well as the vertical extent of the 2017 smoke plume. This data set is relevant to study the effect of these plumes on stratospheric chemistry.