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Impact of wildfire emissions on trace gas and aerosol concentration measured at the Zotino Tall Tower Observatory (ZOTTO) in Central Siberia

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Boreal wildfires are large sources of reactive trace gases and aerosols to the atmosphere, accounting for 20% of carbon emissions from global biomass burning. Siberian wildfires are a major extratropical source of carbon monoxide (CO), as well as a significant source of black carbon, smoke aerosols, and other climate-relevant atmospheric gas/particle species. Smoke particles released by Siberian wildfires could be tracked thousands of kilometers downwind in the entire Northern Hemisphere, perturbing regional to global radiation budgets by influencing light scattering and cloud microphysical processes. The boreal regions of the Northern Hemisphere are expected to experience the largest temperature increases, which will likely increase the severity and frequency of fires.

Consequently, long-term continuous trace gas and aerosol measurements in central Siberia are vital for assessing the atmospheric impact of Siberian boreal fires on regional to global air quality and climate. Since 2006, the Zotino Tall Tower Facility (ZOTTO; www.zottoproject.org), a unique international research platform for large-scale climatic observations, is operational about 20 km west of the Yenisei river (60.8°N; 89.35°E). A 300 m-tall tower allows regular probing of the mixed part of the boundary layer, which is only moderately influenced by diurnal variations of local surface fluxes and thus, in comparison with surface layer, representative for a larger region.

Our investigation of the wildfires' impact on surface air composition in Central Siberia is based on four years of CO/CO_2/CH4 and aerosol particle mass data measured at 300 m a.g.l.. Episodes of atmospheric transport from wildfires upwind of the measurements site are identified based on ensembles of HYSPLIT backward trajectories and MODIS active fire products. The emission factors are calculated using the Carbon Mass Balance method. In an effort to simplify combustion to its most fundamental principles, the combustion efficiency (CE) is used to represent the completeness of combustion. The following general notion is applied: if the CE exceeds 90 %, a fire is typically in the flaming phase, whereas if CE is less than 85 % combustion is in the smoldering phase. Most fires can be considered as being in a "mixed" phase. Ideally, the emission ratios can be obtained by dividing the excess concentrations of trace gas species measured in a fire plume (e.g. CO, CO_2) by the excess concentration of a measured reference gas from the data set. Ground-based CO and CO_2 measurements in plumes from relatively distant fires can usually not be used to extract CO/CO_2 emission ratios due to the uncertain contributions of biogenic CO_2 from respiration to the plume air. We present our attempt to extract CO/CO_2 relationships related to sources from statistical analysis of our data set. The burnt biomass load is taken from the Global Land Cover 2000 project and validated by our in situ data set. Finally, episodes of emissions from the wildfires identified at the given location and time are calculated with a simple bottom-up approach using the equation of Seiler and Crutzen.