Atmospheric Chemistry and Physics
An Interactive Open Access Journal of the European Geosciences Union

Atmos. Chem. Phys., 9, 9315-9327, 2009
www.atmos-chem-phys.net/9/9315/2009/

Wildfire smoke in the Siberian Arctic in summer: source characterization and plume evolution from airborne measurements

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Abstract. We present airborne measurements of carbon dioxide (CO_2), carbon monoxide (CO), ozone (O_3), equivalent black carbon (EBC) and ultra fine particles over North-Eastern Siberia in July 2008 performed during the YAK-AEROSIB/POLARCAT experiment. During a "golden day" (11 July 2008) a number of biomass burning plumes were encountered with CO mixing ratio enhancements of up to 500 ppb relative to a background of 90 ppb. Number concentrations of aerosols in the size range 3.5–200 nm peaked at 4000 cm^{-3} and the EBC content reached 1.4 μg m^{-3}. These high concentrations were caused by forest fires in the vicinity of the landing airport in Yakutsk where measurements in fresh smoke could be made during the descent. We estimate a combustion efficiency of 90 ± 3% based on CO and CO_2 measurements and a CO emission factor of 65.5 ± 10.8 g CO per kilogram of dry matter burned. This suggests a potential increase in the average northern hemispheric CO mixing ratio of 3.0–7.2 ppb per million hectares of Siberian forest burned. For BC, we estimate an emission factor of 0.52 ± 0.07 g BC kg^{-1}, comparable to values reported in the literature. The emission ratio of ultra-fine particles (3.5–200 nm) was 26 cm^{-3} (ppb CO)$^{-1}$, consistent with other airborne studies.

The transport of identified biomass burning plumes was investigated using the FLEXPART Lagrangian model. Based on sampling of wildfire plumes from the same source but with different atmospheric ages derived from FLEXPART, we estimate that the e-folding lifetimes of EBC and ultra fine particles (between 3.5 and 200 nm in size) against removal and growth processes are 5.1 and 5.5 days respectively, supporting lifetime estimates used in various modelling studies.

Final Revised Paper (PDF, 1891 KB) Discussion Paper (ACPD)

Citation: Paris, J.-D., Stohl, A., Nédélec, P., Arshinov, M. Yu., Panchenko, M. V., Shmargunov, V. P., Law, K. S., Belan, B. D., and Ciais, P.: Wildfire smoke in the Siberian Arctic in summer: source characterization and plume evolution from airborne measurements, Atmos. Chem. Phys., 9, 9315-9327, 2009. Bibtex EndNote Reference Manager