Identifying long-range transport of wildfire emissions to the Arctic using a network of ground-based FTIR spectrometers, satellite observations, and transport models

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We present a multi-year time series of the total column amounts of carbon monoxide (CO), hydrogen cyanide (HCN) and ethane (C2H6) obtained by Fourier Transform Infrared (FTIR) spectrometer measurements at ten sites. Six are high-latitude sites: Eureka, Nunavut (80.05°N, 86.42°W); Ny Alesund, Norway (78.92°N, 11.93°E); Thule, Greenland (76.53°N, 68.74°W); Kiruna, Sweden (67.84°N, 20.41°E); Poker Flat, Alaska (65.11°N, 147.42°W); St. Petersburg, Russia (59.88°N, 29.83°E) and four are mid-latitude sites: Bremen, Germany (53.1°N, 8.8°E); Zugspitze, Germany (47.42°N, 10.98°E); Jungfraujoch, Switzerland (46.55°N, 7.98°E) and Toronto, Ontario (43.66°N, 79.40°W).

For each site, enhancements of total column amounts above seasonal means are identified and attributed to wildfire events using HYSPLIT and FLEXPART back-trajectories. Wildfire source locations are identified using the Moderate Resolution Imaging Spectroradiometer (MODIS) fire hot spot dataset while satellite measurements of CO total columns from the Infrared Atmospheric Sounding Interferometer (IASI) illustrate transport of the smoke plume and allow for further confirmation of the observed enhancement. Using the multi-year time series, inter-annual variability of wildfire events is observed. Differences in travel times of the smoke plume between sites allow for ageing of the plume to be determined, providing a means to infer the physical and chemical processes affecting the loss of each species during transport. The varying lifetimes of the species and independent measurements at all sites, along with sensitivities to various source regions given by FLEXPART allow for the transport pathways to the Arctic to be investigated. By accounting for the effect of the ageing of the smoke plumes, the measured FTIR enhancement ratios are corrected to obtain emission ratios and emission factors, which are needed to improve the simulation of fire emissions in chemical transport models.