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# Investigation of CO, $C_2H_6$ and aerosols over Eastern Canada during BORTAS 2011 using ground-based and satellite-based observations and model simulations

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We present the results of total column measurements of CO and $C_2H_6$ and aerosol optical depth (AOD) during the Quantifying the impact of BOReal forest fires on Tropospheric oxidants over the Atlantic using Aircraft and Satellites (BORTAS-B) campaign over Eastern Canada. Ground-based observations, using Fourier transform spectrometers (FTSs) and sun photometers, were carried out in July and August 2011. They were taken in Halifax, Nova Scotia, which is an ideal location to monitor the outflow of boreal fires from North America, and in Toronto, Ontario. Measurements of enhanced fine mode AOD were highly correlated with enhancements in coincident trace gas (CO and $C_2H_6$) observations between 19 and 21 July 2011, which is typical for a smoke plume event.

In this study, we will focus on the identification of the origin and the transport of this smoke plume. We use back-trajectories calculated by the Canadian Meteorological Centre (CMC) as well as FLEXPART forward-trajectories to demonstrate that the enhanced CO, $C_2H_6$ and fine mode AOD seen near Halifax and Toronto did originate from forest fires in Northwestern Ontario, that occurred between 17 and 19 July 2011. In addition, total column measurements of CO from the satellite-borne Infrared Atmospheric Sounding Interferometer (IASI) have been used to trace the smoke plume and to confirm the origin of the CO enhancement. Furthermore, the emission ratio ($ER_{C2H6/CO}$) and the emission factor ($EF_{C2H6}$) of $C_2H_6$ (with respect to the CO emission) were estimated from these ground-based observations. The $C_2H_6$ emission results from boreal fires in Northwestern Ontario agree well with $C_2H_6$ emission measurements from other boreal regions, and are relatively high compared to other geographical regions. The ground-based CO and $C_2H_6$ observations were compared with output from the 3-D global chemical transport model GEOS-Chem, using the inventory of the Fire Locating And Monitoring of Burning Emissions (FLAMBE). Good agreement was found for the magnitude of the enhancement of the total columns of CO between the measured and modelled results; however, a small shift in time of approximately 6 h of the arrival of the plume over Halifax is apparent between the results. The modeled $C_2H_6$ columns are systematically lower than the observations from the ground-based FTSs. It is possible that this difference between the model output and observations is due to the extra-tropical (rather than specific boreal) fire emission ratio used in the GEOS-Chem simulation, which seems to underestimate the $C_2H_6$ emission, derived from the presented ground-based observations. This suggests that a finer categorization of extra-tropical biomass burning is necessary and should be considered in future model simulations.