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Airborne measurements of CO_2, CH_4 and HCN in boreal biomass burning plumes

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Biomass burning plays an important role in the budgets of a variety of atmospheric trace gases and particles. For example, fires in boreal Russia have been linked with large growths in the global concentrations of trace gases such as CO_2, CH_4 and CO (Langenfelds et al., 2002; Simpson et al., 2006). High resolution airborne measurements of CO_2, CH_4 and HCN were made over Eastern Canada onboard the UK Atmospheric Research Aircraft FAAM BAe-146 from 12 July to 4 August 2011. These observations were made as part of the BORTAS project (Quantifying the impact of BOReal forest fires on Tropospheric oxidants over the Atlantic using Aircraft and Satellites). Flights were aimed at transecting and sampling the outflow from the commonly occurring North American boreal forest fires during the summer months and to investigate and identify the chemical composition and evolution of these plumes. CO_2 and CH_4 dry air mole fractions were determined using an adapted system based on a Fast Greenhouse Gas Analyser (FGGA, Model RMT-200) from Los Gatos Research Inc, which uses the cavity enhanced absorption spectroscopy technique. In-flight calibrations revealed a mean accuracy of 0.57 ppmv and 2.31 ppbv for 1 Hz observations of CO_2 and CH_4, respectively, during the BORTAS project. During these flights a number of fresh and photochemically-aged plumes were identified using simultaneous HCN measurements. HCN is a distinctive and useful marker for forest fire emissions and it was detected using chemical ionisation mass spectrometry (CIMS). In the freshest plumes, strong relationships were found between CH_4, CO_2 and other tracers for biomass burning. From this we were able to estimate that 8.5 ± 0.9 g of CH_4 and 1512 ± 185 g of CO_2 were released into the atmosphere per kg of dry matter burnt. These emission factors are in good agreement with estimates from previous studies and can be used to calculate budgets for the region. However for aged plumes the correlations between CH_4 and other biomass burning tracers were not as robust, most likely due to mixing from other CH_4 emission sources, such as the wetland regions. The role of additional emission sources will be investigated using the UK Met Office NAME atmospheric dispersion model and the HYSPLIT trajectory model. Using tailored back trajectory analysis, we will present an interpretation of this new dataset in the context of air mass/fire origin, relating this to MODIS fire maps and source strength.

Langenfelds et al.: Interannual growth rate variations of atmospheric CO_2 and its $\delta^{13}C$, H_2, CH_4, and CO between 1992 and 1999 linked to biomass burning, Global Biogeochem. Cycles, 16, 1048, 2002.

Simpson et al.: Influence of biomass burning during recent fluctuations in the slow growth of global tropospheric methane, Geophysical Research Letters, 33, L22808, 2006.