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Emissions of greenhouse gases and selected volatile organic compounds from UK moorland burning estimated using open-path FTIR spectrometry and burnt area measures.

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In the UK, approximately 3,000 km^2 of heather moorland is managed by controlled burning (muirburn), with individual heather patches of between 0.2 and 10 ha in area subject to burning on a seasonal rotational basis. This management plan amounts to an annual total of 120 - 360 km^2 of heather moorland burning each year. Full assessment of the atmospheric effects of such open vegetation fires generally requires spatio-temporally resolved data on the chemical makeup and magnitude of the smoke emissions. This is usually obtained via multiplication of the amount of fuel consumed [M] by an emission factor [EF_x], representing the amount of chemical species [x] released per kilogram of dry fuel burned. Unfortunately, emission factors for heather burning muirburns do not yet exist. This work details new emission factors for muirburns, derived via open-path Fourier Transform Infrared (OP-FTIR) spectroscopic measurements of the muirburn smoke plumes.

In March 2010, two moorland sites near Debdon in Northumberland, UK, were used for a series of experimental controlled burns. These burns are intended to be the first in a series of experimental UK burns designed for studying emissions from rural fires. The OP-FTIR system was positioned downwind of each experimental fire plot. The spectrometer was aligned to view an infrared lamp located at a distance of 20 - 80 m and along a path approximately parallel to the burning plot edge. As smoke advects across the spectrometer-lamp path, the IR absorption by the various smoke constituents is recorded in the measured spectra. The position and depth of the absorption features are then analysed to retrieve the total number of molecules of each key IR absorbing gas species present in the open-path, from which emission ratios and emission factors are then derived.

Using a spectral forward model coupled to a non-linear least squares fitting procedure, the IR spectra were used to derive the pathlength-amounts of CO_2, CO, CH_4, NH_3, C_2H_4, C_2H_6 and CH_2O at six different muirburn fires. The emission ratio of each gas to CO_2 was used to first establish emission ratios and then emission factors for each gas species, using the carbon mass balance approach. The variation in emission factors for both heather and gorse fires was examined, along with the variability caused by differing combustion efficiencies and fuel (vegetation) chemical composition.

To calculate total UK moorland emissions, it is necessary to multiply the derived emission factors (EF_x) by the total amount of fuel consumed by moorland burning (M). To estimate total fuel consumption, estimates of total UK moorland burnt area are taken from the UK's National Atmospheric Emission Inventory and were multiplied by estimates of fuel density and combustion completeness, derived from data on historic burns in both Northumberland and the Peak District National Park. These calculations represent the first reliable, full measurement-based estimates of the total mass of CO_2, CO, CH_4, NH_3, C_2H_4, C_2H_6 and CH_2O emitted by UK moorland burning.