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Laboratory and field evidence for photochemical production of carbon monoxide (CO) in polar snow

M.M. Frey (1), N. Brough (1), D.R. Blake (2), A.E. Jones (1), and E.W. Wolff (1)

(1) British Antarctic Survey, Cambridge, United Kingdom (maey@bas.ac.uk), (2) Department of Chemistry, University of California, Irvine, USA

Carbon monoxide (CO) is considered as an indirect greenhouse gas, since increasing levels, e.g. by anthropogenic activities, will deplete hydroxyl (OH) radical concentrations and thus enhance build up of methane (CH_4). Through its interactions with OH, CO concentrations also influence atmospheric oxidizing capacity. Recent observations in the mid latitudes of the northern hemisphere suggest that the sun lit snow pack acts as a CO source to the lower troposphere in summer. This aspect of snow photochemistry and snow-atmosphere exchange is likely only of regional importance, but a quantitative assessment of its atmospheric relevance is still lacking.

Here we present new lab results from snow chamber experiments under controlled conditions. Snow samples from Halley, Antarctica (75.58º S, 26.65º W) were irradiated and gas emissions analyzed for CO, ozone (O_3) and formaldehyde (CH_2O). Comparison to experiments under dark conditions and blanks shows significant photolytic production of CO. Observed emission rates per surface area were on the order of 1.7 x 10^{10} molecules $cm^{-2}s^{-1}$. Assuming the typical diurnal variability of atmospheric mixing depth at Halley in summer these translate into CO production rates of 4-26 ppbv day^{-1}. Ambient and firn air measurements of CO from a summer intensive campaign at Summit, Greenland (72.97º N, 38.77º W), another site in the high latitudes, allow to estimate fluxes and yield similar CO production rates of 3-17 ppbv day^{-1}.

Laboratory- and field-based CO formation rates observed in snow are compared with snow concentrations of total organic carbon (TOC) and CH_2O. We discuss feasibility and further research needs of the parameterization of CO emissions from snow surfaces in order to extrapolate to the ice sheet scale.