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Subsurface concentrations and surface emissions of greenhouse gases from a seasonally waterlogged peatland in the UK

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Northern peatlands are globally valuable carbon stocks that can act as either sinks or sources of greenhouse gases (GHGs); carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). We present the results of a year-long field study of subsurface concentrations and surface emissions of CO_2, CH_4 and N_2O in a seasonally flooded, managed lowland fen in the UK. This study aimed to determine the extent to which water status and temperature varies at the site throughout the year and how this affects both the subsurface production and surface emission of GHGs. Measured GHG fluxes were compared to estimations using measured subsurface concentrations with Fick's Law (gradient method). Fick's Law was parameterised with either a measured or a modelled value for the diffusion coefficient for gas transport through soil.

Water-table depth was shown to be a more significant control on surface GHG emissions and subsurface concentrations than ambient temperature. CO_2 emissions increased as the water-table lowered from the surface until 35cm, wherein CO_2 emissions began to decrease once more. This break in the relationship was attributed to low available water for respiration due to drying and competition with plants, and to reduced substrate availability as a result of prolonged optimal respiration conditions. Subsurface CO_2 concentrations showed the opposite relationship with water-table depth, increasing as the water-table moved toward the surface. Both CH_4 emissions and subsurface concentrations showed an exponential relationship with water-table depth, increasing dramatically as the soil entered a flooded condition. N_2O fluxes were primarily small and negative throughout the course of the year. N_2O concentrations below the surface in the field under ungrazed conditions were shown to be low, decreasing even further under flooded conditions, suggesting full denitrification to N_2. The gradient method overestimated emissions of CO_2, CH_4 and N_2O by up to 500, 200 and 15x respectively. The divergence between subsurface and surface CO_2 became unworkable when combined with an artifact of overestimation discovered when using silicone rubber soil atmosphere collectors in saturated or near saturated soils. Further studies into improved methods for accurate subsurface GHG measurement in waterlogged peat soils are needed.