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A riverine clay cover does not prevent high emissions of carbon dioxide and nitrous oxide from drained grasslands on fen peat

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Drainage is necessary for conventional agriculture on peatlands, but this practice causes high emissions of the greenhouse gases carbon dioxide (CO_2) and nitrous oxide (N_2O). The effect of hydrological conditions and management on greenhouse gas emissions (GHG) from true peat soils is relatively well examined, but there is little data on GHG emissions from peat covered with mineral soil. Such a cover may either be man-made to improve the trafficability of the fields or natural, e.g. due to the sedimentation of riverine clay. Here, we aim to evaluate the effect of hydro-meteorological conditions, management and properties of the mineral cover on the emissions of CO_2, N_2O and methane (CH_4). As the majority of peatlands in North-Western Germany, the study area is artificially drained and used as high-intensity grassland. The fen peat is covered by riverine clay deposited by the river Weser. Six measurement sites have been chosen to represent typical agricultural management, soil properties and hydrological conditions. They differ in the soil organic carbon content of the clay, the occurrence of a ploughed horizon as well as water and agricultural management. We used manual chambers to measure CO_2, CH_4 and N_2O fluxes over a period of two years. CO_2 measurement campaigns using transparent and opaque chambers took place every third or fourth week depending on season. CH_4 and N_2O samples were taken every second week and more frequently after fertilizer application. Surprisingly, CO_2 emissions including harvest and organic fertilisation were very high (26 to 61 t CO_2 ha^{-1} a^{-1}) and strongly depended on the summer groundwater level. Thus, the clay cover does not protect the underlying peat, possibly due to past ploughing into the peat layer. N_2O fluxes were controlled by the interaction of fertilisation, soil moisture and temperature. Peak fluxes occurred after fertilisation under moist conditions and during freeze-thaw cycles. Annual N_2O emissions (8 to 30 kg N_2O-N) from peat soils covered with riverine clay were in the higher range of emissions from true peat soils with comparable fertilisation rates. Due to low groundwater levels, there was a slight uptake of CH_4. Due to both high CO_2 and N_2O fluxes, total GHG balances were high (32 to 73 t CO_2-eq. ha^{-1} a^{-1}) even in comparison to typical grasslands on fen peat and dominated by CO_2 emissions (70-94%).