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Greenhouse gas fluxes from drained organic soils - a synthesis of a large dataset

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Drained peatlands are hotspots of greenhouse gas (GHG) emissions. Agriculture is the major land use type for peatlands in Germany and other European countries, but strongly varies in its intensity regarding groundwater level and agricultural management. Although the mean annual water table depth is sometimes proposed as an overall predictor for GHG emissions, there is a strong variability of its effects on different peatlands.
We synthesized 164 annual GHG budgets for 65 different sites in 13 German peatlands. Land use comprised arable land with different crops (n = 17) and grassland with a management gradient from very intensive use with up to five cuts per year to partially rewetted conservation grassland (n = 48). Carbon dioxide (net ecosystem exchange and ecosystem respiration), nitrous oxide and methane fluxes were measured with transparent and opaque manual chambers. Besides the GHG fluxes, biomass yield, fertilisation, groundwater level, climatic data, vegetation composition and soil properties were measured.
Overall, we found a large variability of the total GHG budget ranging from small uptakes to extremely high emissions (> 70 t CO_2-equivalents/(ha yr)). At nearly all sites, carbon dioxide was the major component of the GHG budget. Site conditions, especially the nitrogen content of the unsaturated zone and the intra-annual water level distribution, dominated the GHG emissions from grassland. Although these factors are influenced by natural conditions (peat type, regional hydrology), they could be modified by an improved water management. In the case of grassland, agricultural management such as the number of cuts had only a minor influence on the GHG budgets. Given comparable site conditions, there was no significant difference between the emissions from grassland and arable land. Due to the large heterogeneity of site conditions and crop types, emissions from arable land are difficult to explain, but management decisions such as the duration of soil cover, fertilisation and ploughing seem to have a larger impact than in the case of grasslands. Overall, at the level of individual peatlands, higher groundwater levels always decreased carbon dioxide and thus total emissions.