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Key to GHG fluxes from organic soils: site characteristics, agricultural practices or water table management?

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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 the groundwater level and the 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. Furthermore, re-wetting measures generally decrease carbon dioxide emissions, but may strongly increase methane emissions.

We synthesized 250 annual GHG budgets for 120 different sites in 13 German peatlands. Carbon dioxide (net ecosystem exchange and ecosystem respiration), nitrous oxide and methane fluxes were measured with transparent and opaque manual chambers. Land management ranged from very intensive use with arable land or grassland with up to five cuts per year to partially or completely re-wetted peatlands. 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, controlled the GHG emissions of the agricultural sites. Although these factors are influenced by natural conditions (peat type, regional hydrology), they could be modified by an improved water management. Agricultural management such as the number of cuts had only a minor influence on the GHG budgets. At the level of individual peatlands, higher water levels always decreased carbon dioxide emissions. In nearly all cases, the trade-off between reduced carbon dioxide and increased methane emissions turned out in favour of the re-wetting measures. Some very high methane emissions were caused by a combination of nutrient-rich site conditions and continuous ponding during the vegetation period.