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How do land use intensity, experimentally increased temperature and water level affect methane and nitrous oxide emissions from a drained fen peatland?

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Rewetting and extensification of peatlands is widely discussed and practiced to reduce losses of CO_2 and N_2O from drained peat soils. But rewetting is known to carry the risk of increased CH_4 emissions. Up to now it is not completely clear how the predicted temperature increase in the face of climate change will alter the N_2O and CH_4 exchange of grasslands on drained peatland soils in the temperate zone. Therefore we investigated the effects of land use intensity, increased groundwater level, increased temperature and the combination of warming and increased groundwater level on CH_4 and N_2O exchange of two grassland sites (intensive and extensive grassland) in a drained fen peatland in southern Germany.

We set up a factorial design on both land use types, on each three treatments, warming, increased water table level and the combination of warming and increased water table level as well as a control site were established. Temperature was manipulated with open-top chambers (OTCs) and water level manipulation was performed using a pumping system and sheet pile walls. The intensive grassland was cut three times in the year, the extensive grassland once in autumn 2011. Cattle slurry and mineral fertilizer (CAN) were deployed on the intensive grassland. Fluxes of CH_4 and N_2O were measured biweekly from December 2010 to January 2012 using opaque static closed chambers.

The annual mean groundwater level (GWL) of the sites without water level manipulation was -41.5 cm b. g. and -30 cm b. g. at the water level manipulated sites on the intensive grassland. On the extensive grassland the GWL of the sites without water level manipulation was -32 cm b. g. and -21.5 cm b. g. at the water level manipulated sites. Air temperature in 0.2 m was increased in 2011 by 0.7 ˚C at the treatments with OTCs on the intensive grassland and by 1.0 ˚C at the treatments with OTCs on the extensive grassland respectively.

The annual cumulative CH_4 exchange ranged from 8.1 $\pm$ 3.8 kg C ha^{-1} yr^{-1} to 36.3 $\pm$ 8.6 kg C ha^{-1} yr^{-1}on the extensive grassland and from -0.1 $\pm$ 0.3 kg C ha^{-1} yr^{-1} to 15.0 $\pm$ 1.9 kg C ha^{-1} yr^{-1} on the intensive grassland. The CH_4 emissions of the treatments with increased water level on the intensive grassland were significantly higher compared to the control and warming sites. No significant differences could be observed between CH_4 emissions of the treatments on the extensive grassland. However, we found a general significant relationship between CH_4 fluxes, groundwater level and temperature.

All sites on the intensive grassland show higher annual emissions of N_2O compared to the sites on the extensive grassland. The annual cumulative N_2O exchange ranged from 3.1 $\pm$ 0.5 kg N ha^{-1} yr^{-1} to 6.1 $\pm$ 0.4 kg N ha^{-1} yr^{-1}on the intensive grassland and from 0.7 $\pm$ 0.1 kg N ha^{-1} yr^{-1} to 1.3 $\pm$ 0.2 kg N ha^{-1} yr^{-1} on the extensive grassland. Significant treatment effects could not be observed for N_2O exchange on both land use types.