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Carbon Dynamics in a Passively Rewetted Fen Peatland: A Two-Year Study

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Peatlands, vital carbon sinks, face significant challenges due to drainage activities, thereby disrupting their natural functions. When drained for agriculture, peatlands release stored carbon into the atmosphere. Rewetting may reduce further carbon emissions and promote carbon sequestration, but restoring anaerobic soil conditions may also promote methane emissions. The rewetting of such nutrient-rich agricultural peatland could lead to different patterns and pathways in terms of GHG balance compared to a more pristine peatland.

In this study, we want to identify the different drivers of net ecosystem exchange (NEE) in a previously drained agricultural fen peatland while rewetting is ongoing. We hypothesize that the increase in the water table will have a positive effect on the carbon balance, i.e. a higher amount of carbon sequestered. We also hypothesize that during different periods, different drivers of the NEE will be dominant and that these drivers do not match with the drivers for methane (CH_4) emissions from the peatland.

Here we present two-year Eddy Covariance data (CO_2 and CH_4) obtained from a fairly wet peatland in Vejrumbro, central Jutland, Denmark. This fen-type peatland was drained in the early last century and used for agriculture. The field became gradually wetter during this century because of land subsidence, and during the period of EC measurements, the water table in the ditches gradually increased (mean water table depth in winter: -0.3 ± 2.8 cm, in summer: -27.5 ± 9.5 cm). This site provides a unique context to explore the impacts of restoration efforts on carbon dynamics. Eddy Covariance data, raw data analysis, meteorological data, and modelling techniques are used to elucidate the temporal patterns of carbon exchange during this rewetting process.

The study utilizes a comprehensive dataset, including high-resolution EC measurements containing net ecosystem exchange (NEE), gross primary productivity (GPP), and ecosystem respiration (Re). The analysis of the combined datasets indicates nuances in carbon fluxes associated with the rewetting process. Meteorological data integration enhances the contextual understanding of environmental drivers influencing carbon dynamics.

Our modelling approach incorporates theoretical concepts to explore the mechanistic underpinnings of carbon exchange in the rewetted peatland, by looking at the annual, seasonal, and monthly drivers of CO_2 and CH_4 fluxes. The effects of air/soil temperature, water table depth, global radiation and vegetation dynamics are assessed on these different timeframes. The preliminary results indicate that the shorter the timeframe, the better the fit of the model compared to the measured data indicating the importance of short-term periodic drivers of CO_2 and CH_4 fluxes. The results also show differences in drivers during the rewetting process. By focusing on two years of rewetting, our research contributes valuable insights into the trajectory of carbon fluxes during the critical early phases of restoration.