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FENFLUX: THE SHORT-TERM CLIMATE RESPONSE OF CARBON DIOXIDE, METHANE AND WATER FLUX FROM A REGENERATING FEN IN EAST ANGLIA, UK

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SUMMARY

Peatlands store approximately 30% of global soil carbon stocks and are frequently carbon dioxide sinks. At the same time, they are a source of methane to the atmosphere because of reduced rates of aerobic decomposition in a perennially waterlogged soil environment. Hence, the role of peatlands in the radiative forcing of the Earth's atmosphere system and their impact on the global climate system is complex. We have measured CO_2, H_2O, CH_4 and energy fluxes using the micrometeorological and eddy covariance (EC) techniques at our monitoring sites at regenerating and semi-natural fen sites at the Wicken Fen Nature Reserve, Cambridgeshire, United Kingdom. We present an investigation of the magnitude of the impacts of restoration and ecosystem responses to climate variability by comparing the two fen ecosystems. This research will lead to a better quantitative understanding of the relationships between fen peatlands and global change.

KEY WORDS: Eddy covariance, carbon dioxide, methane, peatland, climate change

INTRODUCTION

Peatlands are unique wetland ecosystems where peat accumulates slowly due to slow rates of decomposition under more or less waterlogged and anoxic conditions (Rydin and Jeglum, 2006). Peatlands cover an estimated 400 million ha, an area equivalent to 3% of the Earth's total land surface (Strack, 2008). Yet, currently, peatlands globally represent a major store of soil carbon (C) (around a third of the carbon in the world's soil is stored in peatlands, an amount that is more than half the current atmospheric stock of carbon dioxide). They function as both a sink and source of atmospheric carbon dioxide (CO_2) and a source of atmospheric methane (CH_4) (Strack, 2008).

Both CO_2 and CH_4 are potent greenhouse gases and their exchange is strongly determined by peatland ecosystem functioning. The emission of CH_4 results from slow anaerobic biomass decomposition in waterlogged conditions. Atmospheric CH_4 accounts for 15% - 20% of the warming effect of greenhouse gases (IPCC, 2001). Moreover, the global warming potential (GWP) for a 100 year horizon is 23 for CH_4. It is not hard to imagine that if peatlands have a relatively high CH_4 emission then they may contribute to global warming despite their positive CO_2 balance (Whiting and Chanton, 2001). Hence, the role of peatlands in the radiative forcing of the earth's surface and the global climate system is complex.

Large scale environmental changes (i.e. climate changes, drainage for agriculture or forestry, peat harvesting) are associated with significant impacts on peatland carbon balances. As one of the most important environmental changes, a lowered water level (which can be lowered because of climate change or drainage management) may yield a thicker oxic layer leading to more aerobic decomposition and higher rates of CO_2 release. However, a lower water table favours methanotrophy and triggers a strong reduction or even complete cessation of CH_4 emission (Rydin and Jeglum, 2006). In some cases, peatlands drained for forestry may result in the ecosystem still acting as a C sink, although this may not happen over a short period of afforestation and not at all sites (Laine *et al.*, 1996). Conversely, rewetting of peatland for restoration may decrease the rate of peat decomposition, thus increasing the C uptake, but increase the rate of CH_4 emission owing to the re-establishment of anaerobic conditions in the surficial peat layer (Renger *et al.*, 2002). In general, peat harvesting after drainage and drainage for agriculture usually convert peatlands to C sources (Rodhe and Scensson, 1995; Kasimir-Klemedtsson *et al.*, 1997). However, the CH_4 emissions from harvested peatlands are low and may stay at a lower level for a long period until methanogen populations recover (Tuittila *et al.*, 2000). Hence responses of peatland carbon budgets to rewetting restoration have emerged as a relevant and complex question.

In terms of the response of peatland ecosystems to climate change, previous research has indicated that temperature and water level are the two main factors affecting the carbon cycling processes in peatland ecosystems (Blodau, 2002; Vasander and Kettunen, 2006). It has been shown that increasing temperature can increase peat decomposition (Updegraff *et al.*, 2004) and CH_4 emission (Fowler *et al.*, 1995) directly, and may significantly alter C budgets in boreal and temperate peatlands. Moreover, concomitant changes in water levels as a function of climate warming or drainage may lead to an increase in CO_2 emission and, in most cases, a strong reduction in CH_4 emission (Laine *et al.*, 1996). It has been suggested by previous research that an increase of 2ºC would increase CO_2 emissions by up to 30%, whilst a 15–20 cm decrease of the ground water table would increase the CO_2 emission by 50–100% (Silvola *et al.*, 1996). However, climate change is likely to be complex and these impacts on peatland C cycle processes are likely to be interacting and synergistic. The impact of climate changes on peatland C stocks and greenhouse gas exchanges remain poorly understood and quantified.

In our study, we have measured CO_2, H_2O, CH_4 and energy fluxes using the micrometeorological and eddy covariance (EC) techniques at our monitoring sites at regenerating and semi-natural temperate fen sites at the Wicken Fen National Nature Reserve, Cambridgeshire, United Kingdom (Morrison *et al.*, this volume). Our study site at Bakers Fen is a regenerating fen that was formerly under intensive agricultural use. It is now extensively grazed by Konic Ponies and Highland cattle and is an open fen peatland dominated by graminoid species. The other study site at Sedge Fen is a semi-natural fen dominated by grass and sedge species (e.g. *Phragmites australis, Carex and Cladium* spp.) that has never been drained. We present an investigation of the magnitude of the impacts of restoration and their response to climate variability by comparing the two different fen ecosystems. The two sites differ in ecology, the condition and depth of peat, and water level conditions and plant primary productivity. These are key factors influencing C cycling in peatlands. In a comparison of these sites, these two factors need to be considered carefully.

METHODS

EC is one of the most direct methods available for measurements of surface-atmosphere gas fluxes over relatively large ‘footprint’ areas. It also allows measurements of fluxes of sensible heat, latent heat and momentum (Burba and Anderson, 2010). It is widely used to measure heat, water and CO_2 exchange, and is increasingly used to monitor CH_4 and other trace gas fluxes.

In the FENFLUX project, we aim to understand the climate change impact on peatland C stocks and greenhouse gas exchanges. The results that will be presented in this presentation extend the study of Morrison *et al.* (this volume). We investigate whether fen peatlands are CO_2 sinks or sources in response to interannual climatic variability. We have recently upgraded our instrumentation to include a Licor Li7700 open-path methane sensor, and will present results exploring how environmental conditions influence CH_4 emissions at the semi-natural and regenerating fen sites.

RESULTS

This poster will present the first CH_4 measurements at the Bakers Fen site and discuss climatic controls on the CO_2 and CH_4 fluxes observed at the two fenland sites.

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