Multi-annual fluxes of carbon dioxide from an intensively cultivated temperate peatland

Cumming, A. M. J.[1, 2], Balzter, H.[2, 1], Evans, C.[3], Kaduk, J.[1, 2], Morrison, R.[4, 2], and Page, S.[1]

(1) Department of Geography, University of Leicester, UK (amjc1@le.ac.uk), (2) Centre for Landscape and Climate Research, University of Leicester, UK, (3) Centre of Ecology & Hydrology (CEH), Bangor, Wales, (4) CEH, Wallingford, UK

Background

Peatlands contain an estimated one third of all terrestrially stored carbon (C) (Gorham, 1991). East Anglia contains the largest continuous area of lowland fen peatlands in the UK. These long term C stores have largely been drained and converted for agricultural land use over the last 400 years due to high agricultural production potential. Initial drainage of peatlands leads to surface lowering and peat wastage. Prolonged exposure of C dense peat soils to oxygen through continued agricultural management results in sustained losses of CO_2 to the atmosphere (Teh *et al.*, 2011). Increasing population in the UK has potential to further stress productive but rapidly diminishing Grade 1 agricultural land. Improving understanding of land managements impacts on CO_2 emissions from these soils is crucial to improving their longevity as a store of C and as an economic resource.

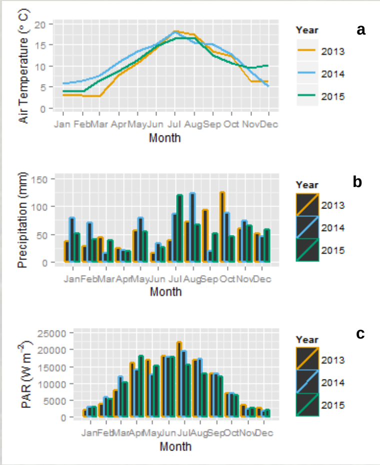

Figure 1. Meteorology data. **a.** Monthly average air temperature, **b.** Monthly sum of precipitation (possible impact from irrigation), **c.** Monthly average Photosynthetically Active Radiation (PAR).

Methodology

Eddy Covariance (EC) is a micrometeorological method whereby turbulent fluxes of heat, mass and momentum in the surface boundary layer are measured to calculate the vertical exchange between the atmosphere and ecosystem beneath it (Baldocchi, 2003). This study utilised an EC flux system consisting of a Li-7500 open path H_2O/CO_2 analyser (Li-COR Inc., Lincoln, Nebraska, USA) and a CSAT3 three-dimensional sonic anemometer (Campbell Scientific, Ltd. Logan, Utah, USA). A suite of complimentary meteorological measurements were made. Raw data were processed using EddyPro® open source software (EddyPro is a registered mark of LI-COR)

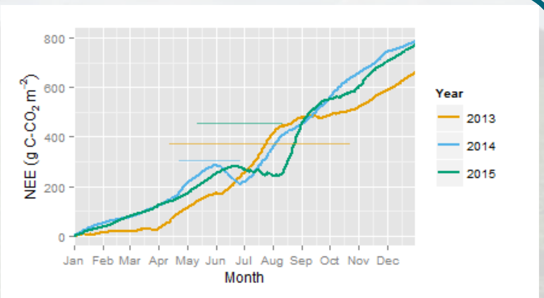

Figure 2. Cumulative 30min Net Ecosystem Exchange (NEE). Positive values denote transfer of C-CO_2 from the biosphere to the atmosphere and negative values uptake by the biosphere (Photosynthesis) .

Horizontal lines indicate periods when crops were present

Study site

Support was given to install instrumentation at Methwold farm, Norfolk. This area of the East Anglian Fen's is separated into field parcels (of roughly 6-8 ha in area) by hedgerows and ditches and dominated by agricultural land practise. Land is intensively managed to produce vegetables including celery, leek, lettuce, radish, maize, onions, potatoes, and sugar beet, and wheat. Measurements were made over three full consecutive years 2013-16, characterised by three crop cycles of leek, lettuce and celery crops partitioned by periods of fallow.

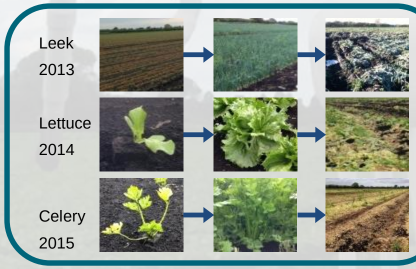

Figure 3. Photos of annual crop cycles

	Crop / fallow 2013	Crop / fallow 2014	Crop / fallow 2015
No. of days	189 / 176 365	58 / 307 365	91 / 274 365
GPP **(g C-CO_2 m^{-2})**	706.73 / 209.21 916	375.83 / 538.46 914.29	669.42 / 338.75 1008.17
ER **(g C-CO_2 m^{-2})**	1150.66 / 423.5 1574.17	379.62 / 1318.09 1697.71	726.70 / 1051.16 1777.86
NEE **(g C-CO_2 m^{-2})**	443.93 / 214.23 658.17	3.79 / 779.63 783.4	57.28 / 712.41 769.69
Import (g Cm^{-2})	-	45.64	49.25
Export (g Cm^{-2})	129.2	36.07	96.49
NEP (g Cm^{-2})	787.37	773.83	816.93

Table 1. Summary of Net Ecosystem Exchange (NEE), Gross Primary Productivity (GPP), Ecosystem Respiration (ER) values for each year of the study, separated into crop and fallow values and accompanied by an account of C imports and exports to the field that are then added to create a Net Ecosystem Production to reflect the rate of C exchange.

Results and Conclusion

High intensity agricultural peatlands are a significant source of CO_2 to the atmosphere.

The study site is an annual source of CO_2 (Figure 2.) but during crop growth becomes a brief sink. Before leek crop planting in April 2013 cumulative NEE was already significantly reduced comparative to consequent years (Figure 2.). This was likely a reflection of temperature (Figure 1a) which could be the leading influence on lower annual NEE in 2013 (Table 1). Furthermore, whilst a secondary cover of weeds was common, treatment of them differed annually, causing varied flux responses.

C import and export via plugs and crops have a significant impact on annual C exchange

Most C is removed from the site with leeks, lettuce is almost neutral and celery is a smaller loss. Once these values are taken into account the NEP of C for 2013 is much more similar to that of the other years (Table 1.).

References: **Baldocchi, D. D., (2003).** Assessing the eddy covariance technique for evaluating carbon dioxide exchange rates of ecosystems: past, present and future, Global Change Biol., 9, 479–492. **Gorham, E., (1991)**. Northern peatlands: Role in the carbon cycle and probable responses to climatic warming, Ecol. Appl., 1, 182–195. **Teh, YA., Silver, WL., Sonnentag, O., Detto, M., Kelly, M. & Baldocchi, DD. (2011).** 'Large greenhouse gas emissions from a temperate peatland pasture'. *Ecosystems*, vol 14, no. 2, pp. 311-325.