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Effects of winter temperature and summer drought on net ecosystem exchange of CO_2 in a temperate peatland

Carole Helfter (1), Claire Campbell (2), Kerry Dinsmore (1), Julia Drewer (1), Mhairi Coyle (1), Margaret Anderson (1), Ute Skiba (1), Eiko Nemitz (1), Michael Billett (1,3), and Mark Sutton (1)

(1) Centre for Ecology and Hydrology, Penicuik, United Kingdom (caro2@ceh.ac.uk), (2) Scottish Environmental Protection Agency, Stirling, United Kingdom, (3) University of Stirling, Stirling, United Kingdom

Northern peatlands are one of the most important global sinks of atmospheric carbon dioxide (CO_2); their ability to sequester C is a natural feedback mechanism controlled by climatic variables such as precipitation, temperature, length of growing season and period of snow cover. In the UK it has been predicted that peatlands could become a net source of carbon in response to climate change with climate models predicting a rise in global temperature of ca. 3^{o}C between 1961-1990 and 2100. Land-atmosphere exchange of CO_2in peatlands exhibits marked seasonal and inter-annual variations, which have significant short- and long-term effects on carbon sink strength.

Net ecosystem exchange (NEE) of CO_2 has been measured continuously by eddy-covariance (EC) at Auchencorth Moss (55˚47'32 N, 3˚14'35 W, 267 m a.s.l.), a temperate peatland in central Scotland, since 2002. Auchencorth Moss is a low-lying, ombrotrophic peatland situated ca. 20 km south-west of Edinburgh. Peat depth ranges from <0.5 m to >5 m and the site has a mean annual precipitation of 1155 mm. The vegetation present within the flux measurement footprint comprises mixed grass species, heather and substantial areas of moss species (*Sphagnum* spp. and *Polytrichum* spp.). The EC system consists of a LiCOR 7000 closed-path infrared gas analyser for the simultaneous measurement of CO_2 and water vapour and of a Gill Windmaster Pro ultrasonic anemometer.

Over the 10 year period, the site was a consistent yet variable sink of CO_2 ranging from -34.1 to -135.9 g CO_2-C m^{-2} yr^{-1} (mean of -69.1 ± 33.6 g CO_2-C m^{-2} yr^{-1}). Inter-annual variability in NEE was positively correlated to the length of the growing seasons and mean winter air temperature explained 93% of the variability in summertime sink strength, indicating a phenological memory-effect. Plant development and productivity were stunted by colder winters causing a net reduction in the annual carbon sink strength of this peatland where autotrophic processes are thought to be dominant. The site is wet throughout most of the year (water table depth < 5 cm below the peat surface), but there are indications that drought enhanced heterotrophic respiration and depressed gross primary productivity (GPP); a sustained drought during the summer of 2010 (maximum water table depth 36 cm below surface) was accompanied by a two-fold increase in total respiration and a 30% decrease in GPP. The cold preceding winter could also have contributed to lowering GPP, and disentangling the confounding adverse effects of drought and winter climate on GPP is thus not straightforward. Whilst 2010 had the smallest NEE in the 2002-2012 period, the largest values were found for years with warm winters and relatively wet growing seasons. A simple parameterisation of the effects of PAR on GPP of and air temperature on ecosystem respiration, suggest that a rise in air temperature of 1˚C between 2012 and 2065 could lead to a 73% increase in the carbon sink strength of the peatland, provided hydrological conditions remain unchanged. This demonstrates that climate change is not likely to change this peatland into a carbon source by 2100.