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# From sink to source: long-term (2002-2019) trends and anomalies in net ecosystem exchange of CO2 from a Scottish temperate peatland.

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Peatlands North of 45˚ represent one of the largest terrestrial carbon (C) stores. They play an important role in the global C-cycle, and their ability to sequester carbon is controlled by multiple, often competing, factors including precipitation, temperature and phenology. Land-atmosphere exchange of carbon dioxide ($CO_2$) is dynamic, and exhibits marked seasonal and inter-annual variations which can effect the overall carbon sink strength in both the short- and long-term.

Due to increased incidences of climate anomalies in recent years, long-term datasets are essential to disambiguate natural variability in Net Ecosystem Exchange (NEE) from shorter-term fluctuations. This is particularly important at high latitudes (>45˚N) where the majority of global peatlands are found. With increasing pressure from stressors such as climate and land-use change, it has been predicted that with a ca. 3$^{o}$C global temperature rise by 2100, UK peatlands could become a net source of C.

NEE of $CO_2$ has been measured using the eddy-covariance (EC) method at Auchencorth Moss (55°47'32 N, 3°14'35 W, 267 m a.s.l.), a temperate, lowland, ombrotrophic peatland in central Scotland, continuously since 2002. Alongside EC data, we present a range of meteorological parameters measured at site including soil temperature, total solar and photosynthetically active radiation (PAR), rainfall, and, since April 2007, half-hourly water table depth readings. The length of record and range of measurements make this dataset an important resource as one of the longest term records of $CO_2$ fluxes from a temperate peatland.

Although seasonal cycles of gross primary productivity (GPP) were highly variable between years, the site was a consistent $CO_2$ sink for the period 2002-2012. However, net annual losses of $CO_2$ have been recorded on several occasions since 2013. Whilst NEE tends to be positively correlated with the length of growing season, anomalies in winter weather also explain some of the variability in $CO_2$ sink strength the following summer.

Additionally, water table depth (WTD) plays a crucial role, affecting both GPP and ecosystem respiration ($R_{eco}$). Relatively dry summers in recent years have contributed to shifting the balance between $R_{eco}$ and GPP: prolonged periods of low WTD were typically accompanied by an increase

in $R_{eco}$, and a decrease in GPP, hence weakening the overall $CO_2$ sink strength. Extreme events such as drought periods and cold winter temperatures can have significant and complex effects on NEE, particularly when such meteorological anomalies co-occur. For example, a positive annual NEE occurred in 2003 when Europe experienced heatwave and summer drought. More recently, an unusually long spell of snow lasting until the end of March delayed the onset of the 2018 growing season by up to 1.5 months compared to previous years. This was followed by a prolonged dry spell in summer 2018, which weakened GPP, increased $R_{eco}$ and led to a net annual loss of 47.4 ton $CO_2$-C $km^{-2}$. It is clear that the role of Northern peatlands within the carbon cycle is being modified, driven by changes in climate at both local and global scales.