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Effects of ploughing on land-atmosphere exchange of greenhouse gases in a managed temperate grassland in central Scotland

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Grasslands are important ecosystems covering $>$ 20% and $>$ 30% of EU and Scotland's land area respectively. Management practices such as grazing, fertilisation and ploughing can have significant short- and long-term effects on greenhouse gas exchange. Here we report on two separate ploughing events two years apart in adjacent grasslands under common management.

The Easter Bush grassland, located 10 km south of Edinburgh (55°52'N, 3°2'W), comprises two fields separated by a fence and is used for grazing by sheep and cattle. The vegetation is predominantly *Lolium perenne* ($>$ 90%) growing on poorly drained clay loam. The fields receive several applications of mineral fertiliser a year in spring and summer. Net ecosystem exchange (NEE) of carbon dioxide (CO_2) has been monitored continuously by eddy-covariance (EC) since 2002 which has demonstrated that the site is a consistent yet variable sink of atmospheric CO_2. The EC system comprises a LI-COR 7000 closed-path analyser and a Gill Instruments Windmaster Pro ultrasonic anemometer mounted atop a 2.5 m mast located along the fence line separating the fields. In addition, fluxes of nitrous oxide (N_2O), methane (CH_4)and CO_2were measured with static chambers installed along transects in each field. Gas samples collected from the chambers were analysed by gas chromatography and fluxes calculated for each 60-minute sampling period.

The ploughing events in 2012 and 2014 exhibited multiple similarities in terms of NEE. The light response (i.e. relationship between CO_2 flux, and photosynthetically active radiation, PAR) of the NF and SF during the month preceding each ploughing event was of comparable magnitude in both years. Following ploughing, CO_2 uptake ceased in the ploughed field for approximately one month and full recovery of the photosynthetic potential was observed after ca. 2 months. During the month following the 2014 ploughing event, the ploughed NF released on average 333 $\pm$ 17 mg CO_2-C m^{-2} h^{-1}. In contrast, the SF net uptake during the same period was -79 $\pm$ 19 mg CO_2-C m^{-2} h^{-1}. Ploughing caused a net release of carbon of 183 g CO_2-C m^{-2} during the month following ploughing, thus turning the grassland into a potent CO_2 source. Chamber measurements of CH_4 and N_2O exhibited high spatial variability in 2012 and no statistical difference could be established between fields and treatments. CH_4 fluxes were high in both fields after ploughing which was presumably linked to air temperature. N_2O fluxes in the ploughed SF reached on average 100 μg N_2O-N m^{-2} h^{-1} 29 days after ploughing which corresponded to ca. 20 times the background level recorded at the site. Fluxes of N_2O were however considerably larger in 2014, peaking at 2570 μg N_2O-N m^{-2} h^{-1} 29 days after ploughing. Contrarily to 2012, substantial and statistically significant CH_4 emissions were recorded in 2014 in the ploughed field. Whilst spatial variability was high in both years it can nevertheless be concluded that ploughing had substantial adverse short term effects on emissions and that environmental conditions greatly impacted the magnitude of CH_4 and N_2O fluxes.