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

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Fig. 1: Experimental field sites at Easter Bush, Scotland. 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. The locations of the temporary EC systems used for the 2012 and 2014 ploughing events are marked EC 2012 and EC 2014.

Introduction: 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 (GHG) exchange. Here we report on two separate ploughing events two years apart (2012 and 2014) in adjacent grasslands under common management.

Methods: 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. 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. In addition, fluxes of nitrous oxide (N_2O), methane (CH_4) and CO_2 were 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.

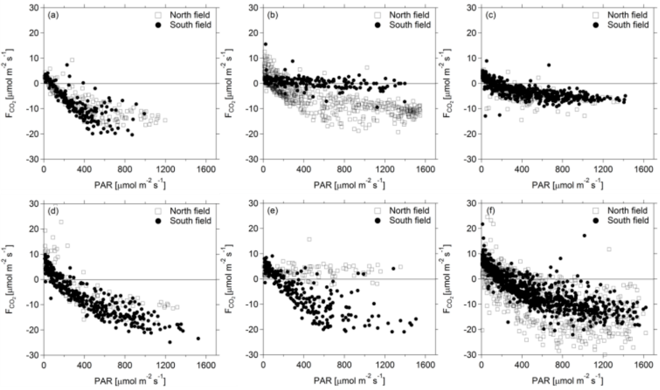

Fig. 2: Light response (F_{CO2} vs. PAR) obtained for (a)-(c) one month prior, one and 2 months after ploughing of the south field in 2012, respectively; (d)-(f) as (a)-(c) in 2014.

Results: 1) CO_2 fluxes

- CO_2 uptake resumes ca. 1 – 1.5 months after ploughing.
- Full recovery of CO_2 sink strength after 2 months.
- No significant difference in photosynthetic capacity between old and new grass.
- Large increase in soil respiration after ploughing (peak 30 minutes after plough passed; 1 order of magnitude larger than after 3 hours).
- Respiration ratio (ploughed/non-ploughed) = 0.8 at 15 °C (i.e. heterotrophic respiration is the dominant term).
- During the month following the 2014 ploughing event, the ploughed NF released on average 333 ± 17 mg CO_2-C m^{-2} h^{-1}. In contrast, the SF net uptake during the same period was -79 ± 19 mg CO_2-C m^{-2} h^{-1}.

2) CH_4 fluxes

- High spatial variability across static chambers.
- Background fluxes in range – 30 to + 30 µg CH_4-C m^{-2} h^{-1} in both fields.
- Increase in fluxes coincided with warmer, wetter weather.
- Ploughed fields released more CH_4 than unploughed fields during warm weather (1 order of magnitude difference).

3) N_2O fluxes

- High spatial variability across static chambers in both fields and years.
- Background fluxes < 10 µg N_2O-N m^{-2} h^{-1} in both fields and years.
- 2014 fluxes increased to ca. 800 µg N_2O-N m^{-2} h^{-1} after harrowing and rolling (6 days after ploughing); peak after 17 days, fluxes high in all chambers.
- N_2O fluxes from ploughed field > unploughed in 2014. No significant difference in 2012.
- N_2O fluxes generally higher in warmer weather (no statistically significant correlation).
- N_2O fluxes in 2012 did not appear to respond directly to ploughing whilst they did in 2014.

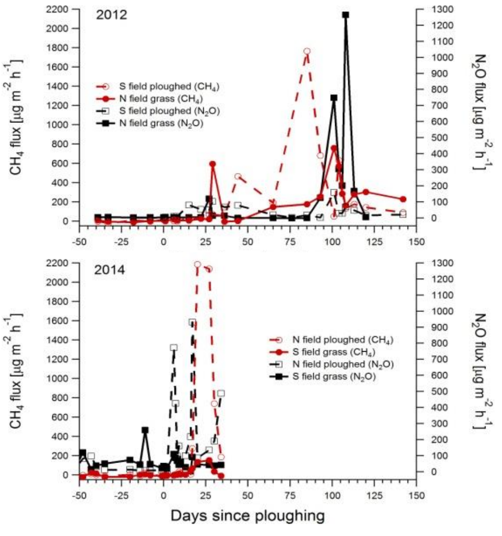

Fig. 3: Methane (CH_4) and nitrous oxide (N_2O) fluxes measured by static chambers in adjacent ploughed and non-ploughed fields in 2012 and 2014.

Conclusions:

- Ploughing caused a net release of CO_2 of 183 g CO_2-C m^{-2} during the month following ploughing (removal of CO_2 sink).
- Short-term enhancement of CH_4 fluxes as a result of ploughing (effect on N_2O observed in 2014 only).
- Meteorological conditions (rainfall, temperature) more than management controlled the magnitude of N_2O and CH_4 fluxes.
- Spatially-integrated and temporally-resolved measurements (eddy-covariance) needed to better constrain spatial variability in CH_4 and especially N_2O fluxes and detangle effects of management and hydro-meteorological controls.

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