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A MOBILE AUTOMATIC GAS CHROMATOGRAPH SYSTEM TO MEASURE CO_2, CH_4 AND N_2O FLUXES FROM SOIL IN THE FIELD

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A caravan has been converted into a mobile laboratory for measuring fluxes of CO_2, CH_4 and N_2O from the soil in the field. The caravan is equipped with a gas chromatograph fitted with TC-, FI- and EC-detectors, and a PC controlled data logger. The gas collecting chambers can be used up to 50 m from the caravan. The closing and opening of the chambers, as well as the flows of sample gases from chambers to the gas chromatograph, is pneumatically regulated. Simultaneous recordings of temperature, light intensity and the depth of water table are made. The system has been used for two months in 1992, and some preliminary results are presented.

Keywords: Automated measuring, carbon dioxide, methane, nitrous oxide, peatland

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INTRODUCTION

In most trace gas flux field studies, the gas samples are collected in closed chambers and taken back to the laboratory for analysis (e.g. Svensson & Rosswall 1984, Crill et al. 1988, Moore & Roulet 1991). The procedure is very laborious and there may be considerable delays between the time of sample collection and analysis. In some of the SILMU projects, gas fluxes have been measured every 1–4 weeks in 25 study sites (Martikainen et al. 1992). In this way, general rates and trends of annual changes in gas fluxes can be obtained for many different site types, but short-term fluctuations in fluxes are missed. Such fluctuations are caused by rapid changes in environmental conditions, e.g. the diurnal fluctuation in light and temperature, changes of the air pressure, heavy rain or thawing of the frost.

To investigate such short-term changes in gas fluxes at some of the sites during the second phase of the SILMU program, a mobile automatic gas chromatograph system has been built at the University of Joensuu with support from the National Public Health Institute at Kuopio.

DESCRIPTION OF THE SYSTEM

A caravan has been converted into a mobile gas chromatograph laboratory. Inside the caravan is a gas chromatograph which is fitted with TC-, FI- and EC-detectors capable of analyzing for CO_2, CH_4 and N_2O simultaneously (Fig. 1). The gas chromatograph is controlled by a PC control unit equipped with data acquisition boards.

Six chambers are attached to the gas chromatograph, which can be extended to a maximum distance of 50 m from the caravan. The chambers (Fig. 2) operate pneumatically and the flow of sample gas is controlled by magnetic valves. When a chamber is closed, the valves are open and air is circulated between the chamber and the gas chromatograph. A sample of the air is injected into the gas chromatograph at five minute intervals during a 20-minute measurement period.

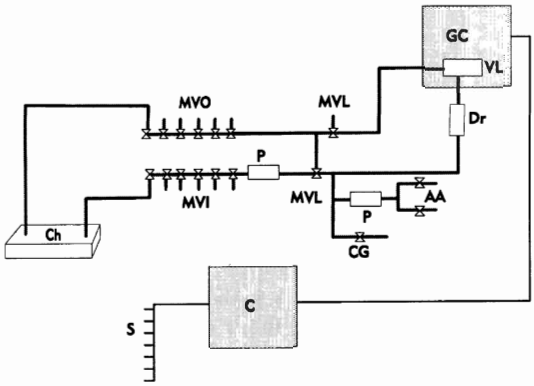


Fig. 1. The principle of the automatic gas chromatograph system. The chambers (Ch, only one of six shown here) are pneumatically operated. The sample gas is circulated via the magnetic valves (MVI = sample from the chamber, MVL, VL, and MVO = sample back) to the gas cromatograph (GC). Other abbreviations: P = pump, Dr = gas drying, AA = ambient air samples, CG = calibration gas, C = computer, S = sensors for measuring of environmental conditions.

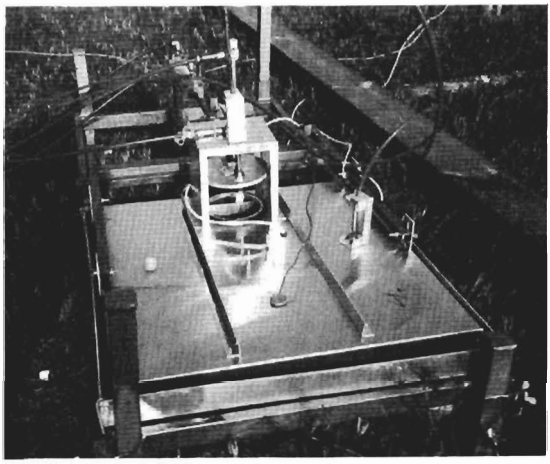


Fig. 2. The chamber is closed and opened with pneumatical pistons. To prevent the disturbing effects of the pressure change, the chamber is closed in two phases: first, the chamber is put down carefully (water sealing), and then the hole is closed.

During every measurement period, calibration gases are analyzed and new calibration coefficients calculated. In normal use, the gas fluxes in six chambers can be measured 4–5 times per day.

Air and surface peat temperatures and the level of water table are automatically measured at the same time as the gas chromatograph measurements. In addition, the ambient gas concentrations (two heights), peat temperatures (3 depths) and light intensity are measured at one location.

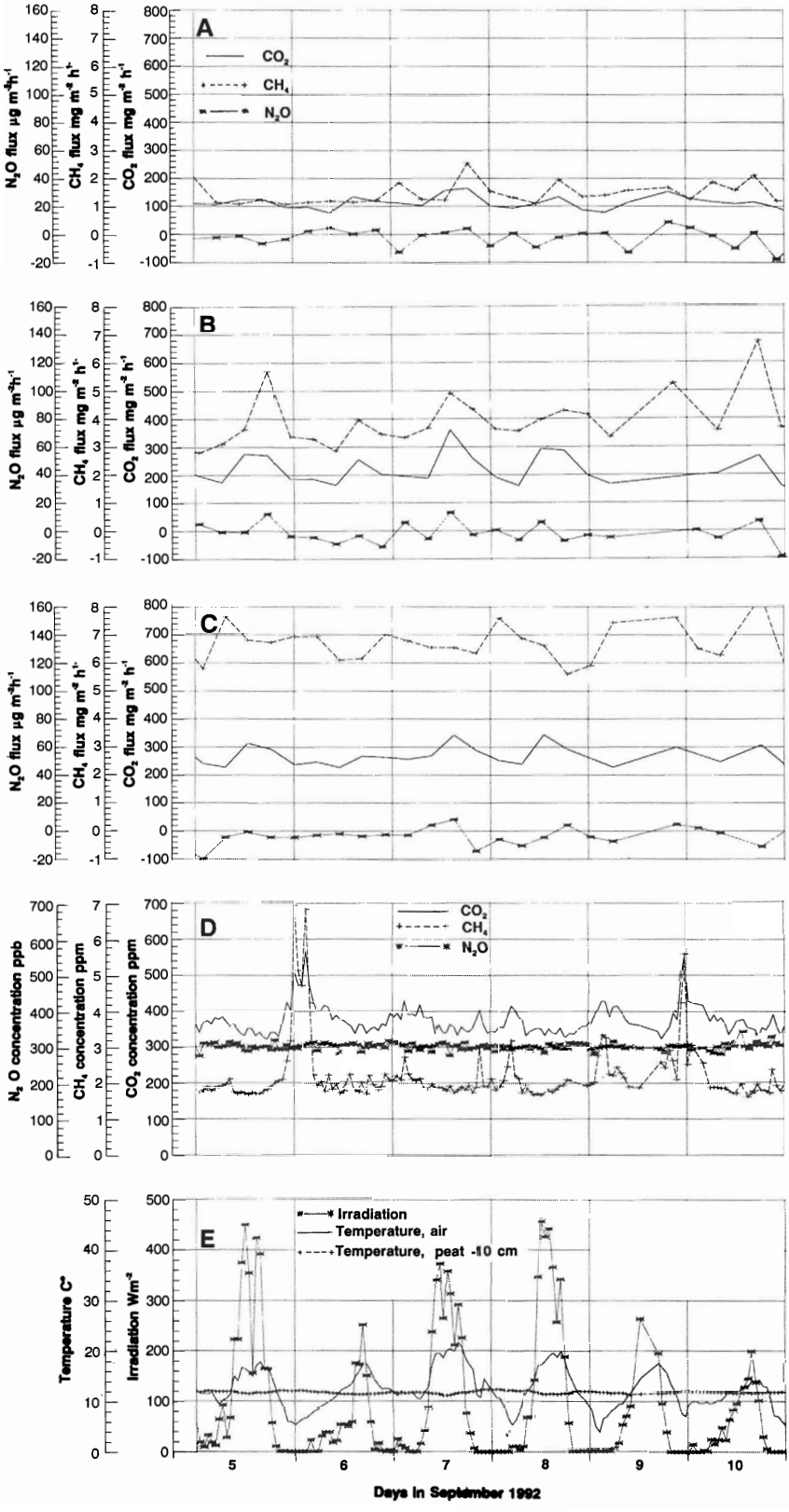
RESULTS AND DISCUSSION

The system was in use in August–October 1992 at a study site, Salmisuo, in Ilomantsi. Salmisuo is a virgin *Sphagnum papillosum* fen. Three chambers were placed on hummocks with the water levels of 10–30 cm and on lawn surfaces with water levels of 0–10 cm. During the measuring period, the variation in water table depth was small and temperatures varied from c. –5 to +25°C.

At the end of August, when the air temperature was generally 10 to 20°C, CO_2 fluxes were 100–300 mg $m^{-2}h^{-1}$. At the end of October, when the temperatures were –5 to +5°C, CO_2 fluxes were 20–80 mg $m^{-2}h^{-1}$. CH_4 fluxes also decreased, but less so. In August, CH_4 fluxes were 0.4–4 mg $m^{-2}h^{-1}$ on hummocks and 6–9 mg $m^{-2}h^{-1}$ on lawns. Corresponding values in October were 0.3–3 mg $m^{-2}h^{-1}$ and 3–6 mg $m^{-2}h^{-1}$. N_2O fluxes were very small during the whole period (–20 to + 20 µg $m^{-2}h^{-1}$), and there were few times when the fluxes were statistically significant ($P \leq 0.05$). The levels of gas fluxes were of the same magnitude as averages reported by Martikainen et al. (1992) using a manual static chamber method for corresponding mire sites.

Daily CO_2 production clearly followed the changes in temperature and the fluxes were often 30–50% higher during the day than during the night (Fig. 3). The increase in temperature can

Fig. 3A–E (Right). An example of the gas fluxes in September 1992. A: *Sphagnum fuscum* hummock, water level 30 cm, B: *S. fuscum* hummock, water level 10 cm, C: *S. papillosum–S. angustifolium* lawn, water level 5 cm. The ambient gas concentrations in air 30 cm above the peat surface (D), the irradiation and the temperatures in air and peat (E) are also shown.


A
B
C
D
E
CO2
CH4
N2O
N2O flux µg m-2h-1
CH4 flux mg m-2 h-1
CO2 flux mg m-2 h-1
N2O concentration ppb
CH4 concentration ppm
CO2 concentration ppm
Irradiation
Temperature, air
Temperature, peat -10 cm
Temperature C°
Irradiation W/m-2
Days in September 1992

affect CO_2 fluxes by accelerating biological processes and by increasing the diffusion rate of CO_2 from soil (Schlesinger 1977). A slight daily fluctuation in CH_4 fluxes could be discerned in hummocks but not in lawns. CH_4 flux temperature dependence was expected to be small because CH_4 is produced deeper in anaerobic peat layers where the daily temperature changes are small. As the net flux of CH_4 is the difference between CH_4 production and oxidation, the dependence of net CH_4 flux on temperature can vary. If the temperature effect on CH_4 oxidation exceeds that on CH_4 production and diffusion, the relationship between net CH_4 flux and temperature could be opposite to that we found. No daily fluctuations in N_2O fluxes could be seen. Gas emissions from the peat increased ambient gas concentrations above the soil surface, especially during calm nights (cf. Silvola 1986).

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