

Evaluation of a Closed-Path Fourier Transform Infra-Red (FTIR) Multi-Component Gas Analyzer for the Simultaneous Measurement of Nitrous Oxide, Carbon Dioxide and Methane

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Introduction

- Measuring GHG (N₂O, CH₄, and CO₂) emissions from soils often involves the collection of discrete gas samples from chamber-based sampling systems, with the samples subsequently analyzed in a laboratory setting using gas chromatography.
- There is a need to deploy gas analysis systems in the field, especially in remote locations.
- Field-based measurements include micrometeorological techniques (e.g., Eddy covariance) and *in-situ* chamber-based systems that employ infrared gas analysis (IRGA), photoacoustic spectroscopy (PAS) or Fourier transform infrared (FTIR) spectroscopy.
 - IRGA systems are well established for the quantification of CO₂ fluxes from soils.
 - PAS and FTIR analyzers are capable of the simultaneous measurement of N₂O, CH₄, and CO₂.
- Whereas performance of PAS has been demonstrated, the performance of FTIR methods of measuring near-ambient GHG concentrations has yet to be validated under either controlled or field conditions.

Objectives

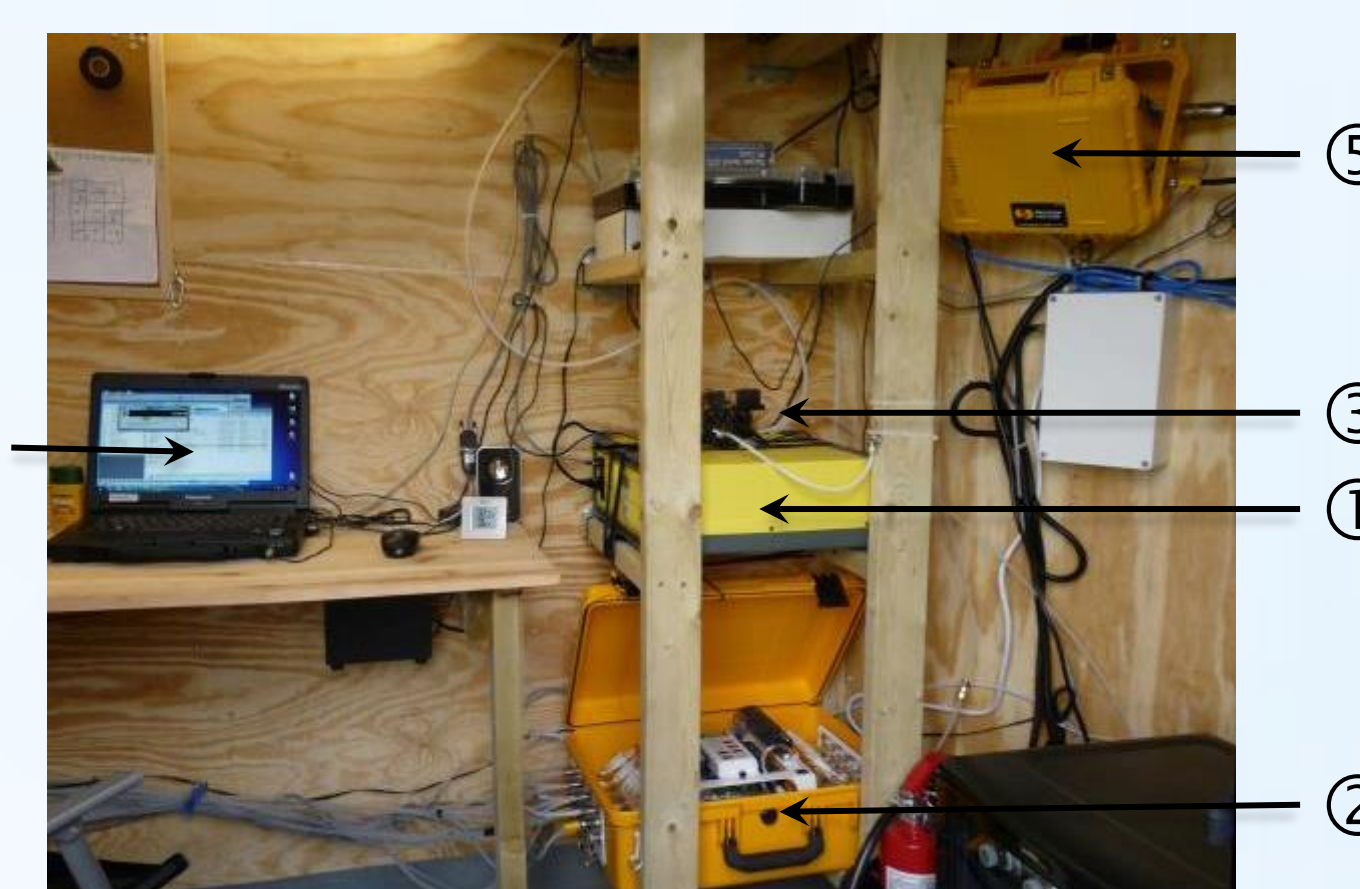
- Evaluate the performance of a FTIR-multi-gas analyzer in terms of its response (including accuracy, precision, and linearity) to N₂O, CH₄, and CO₂; the effects of water vapor on gas concentration measurements; and comparison of gas fluxes measured using FTIR and GC techniques.

FTIR multi-gas analyzer

- Gasetm DX-4015 multi-component gas analyzer (FTIR-MGA; Gasetm Technologies Inc. Helsinki, Finland)
 - FTIR spectrometer (resolution = 8 cm⁻¹; scan frequency = 10 scans s⁻¹; wave number range = 900-4200 cm⁻¹)
 - rhodium-gold coated sample cell (multi-pass with a fixed path length of 9.8 m and a volume of 0.45 L)
 - built-in sample pump (2.8 L min⁻¹)
 - sample processing electronics and Calcmet™ software
 - rugged, field portable aluminum case

Automated GHG Flux Measurements

- The automated soil greenhouse gas flux measurement system consisted of:
 - Gasetm DX-4015 FTIR-MGA
 - Li-Cor LI-8150-16 multiplexer (operating 16 Li-Cor LI-8150-104 long-term flux chambers)
 - Custom-built zero-air and calibration gas valve
 - Laptop computer running the Calcmet™ software and custom control software to operate the multiplexer and zero-air/calibration gas valve
 - Custom-built communications interface for the PC/multiplexer
 - Trailer to house system in the field



FTIR Performance

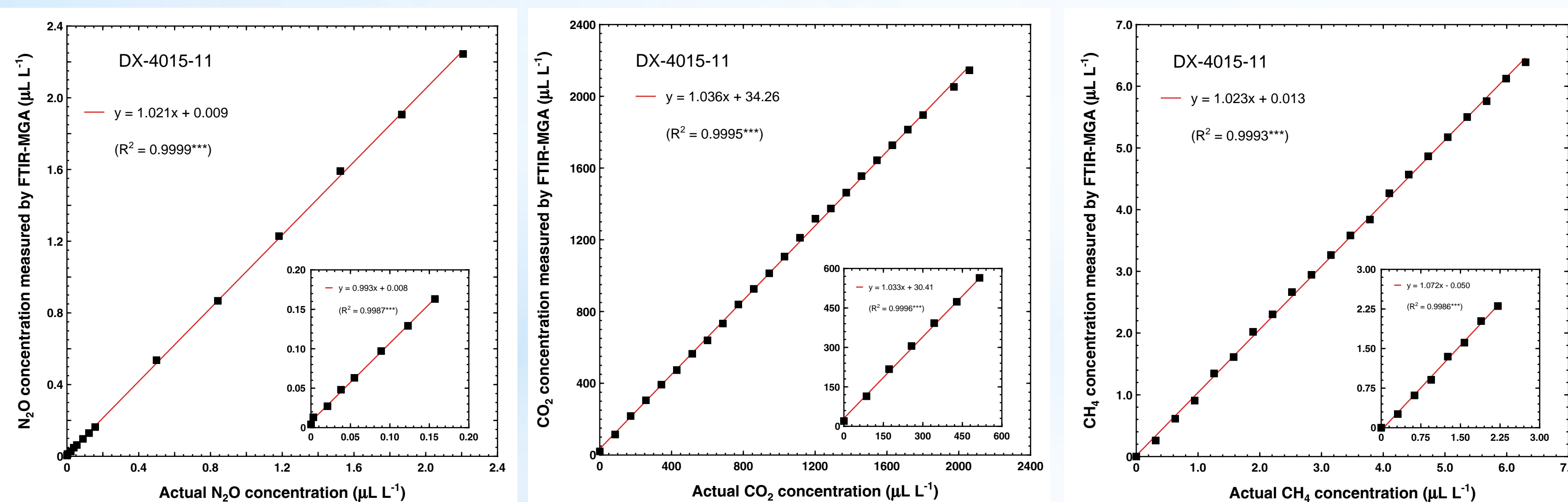


Fig 1. Nitrous oxide (N₂O), carbon dioxide (CO₂) and methane (CH₄) concentrations measured using a Gasetm DX-4015 FTIR-MGA vs. the calculated gas concentration. Gas concentration was measured continuously from a chamber into which the gases were injected. Note: only the response in the near-ambient range is shown.

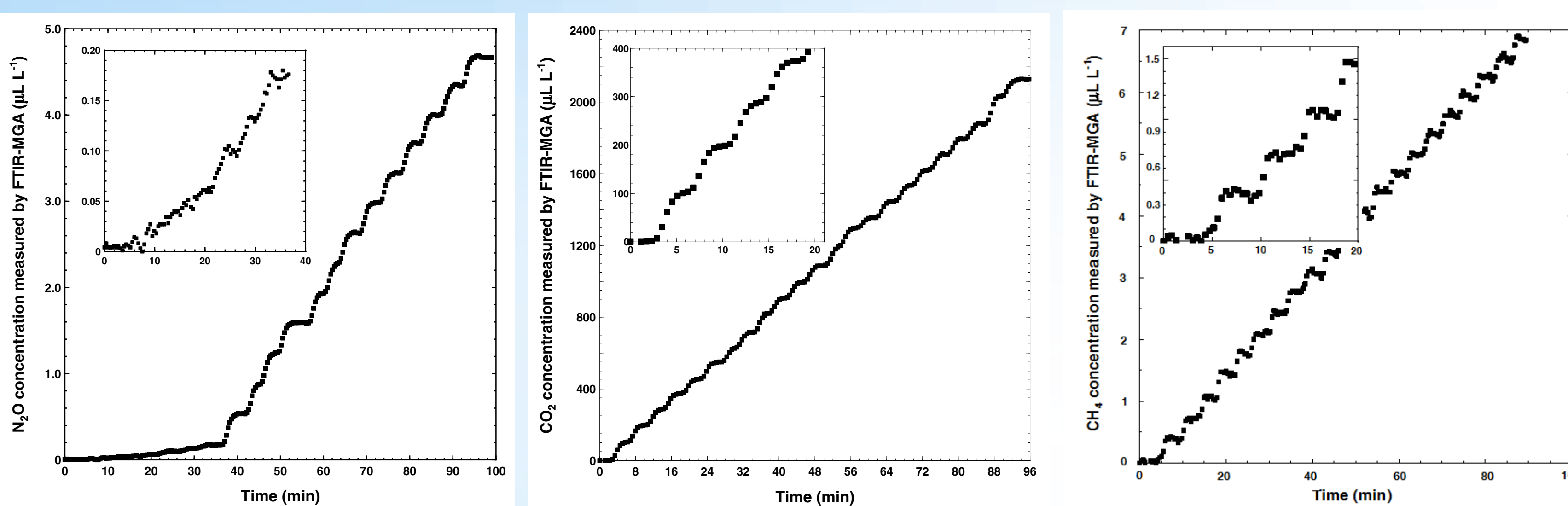


Fig 2. Response of the Gasetm DX-4015 FTIR-MGA to increasing concentrations of nitrous oxide (N₂O), carbon dioxide (CO₂) and methane (CH₄). Complete infrared spectra were collected continuously (at 100 ms intervals) and averaged over 20-s measurement intervals.

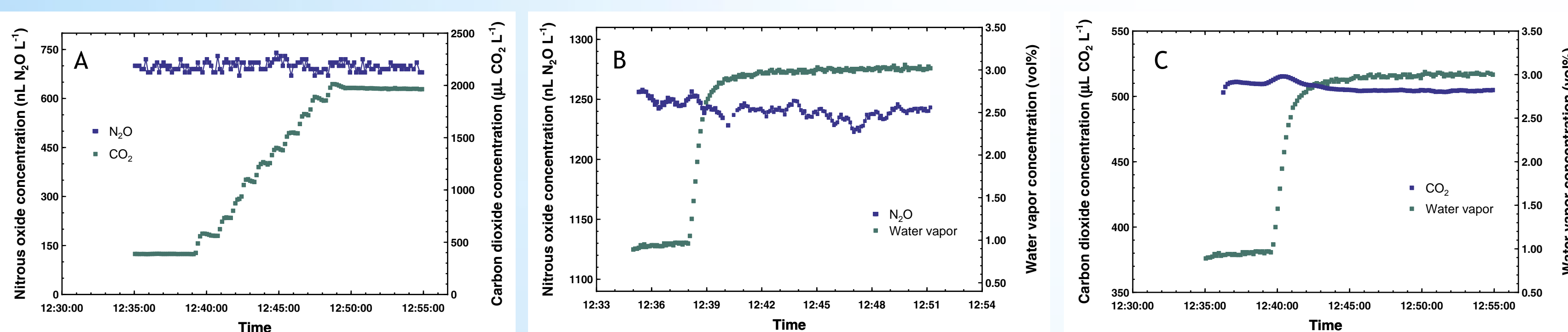


Fig 3. Effect of increasing CO₂ concentration on stability of the N₂O measurement (A); effect of increasing water vapor concentration on stability of the N₂O measurement (B) or CO₂ measurement (C).

Automated GHG Flux Measurements

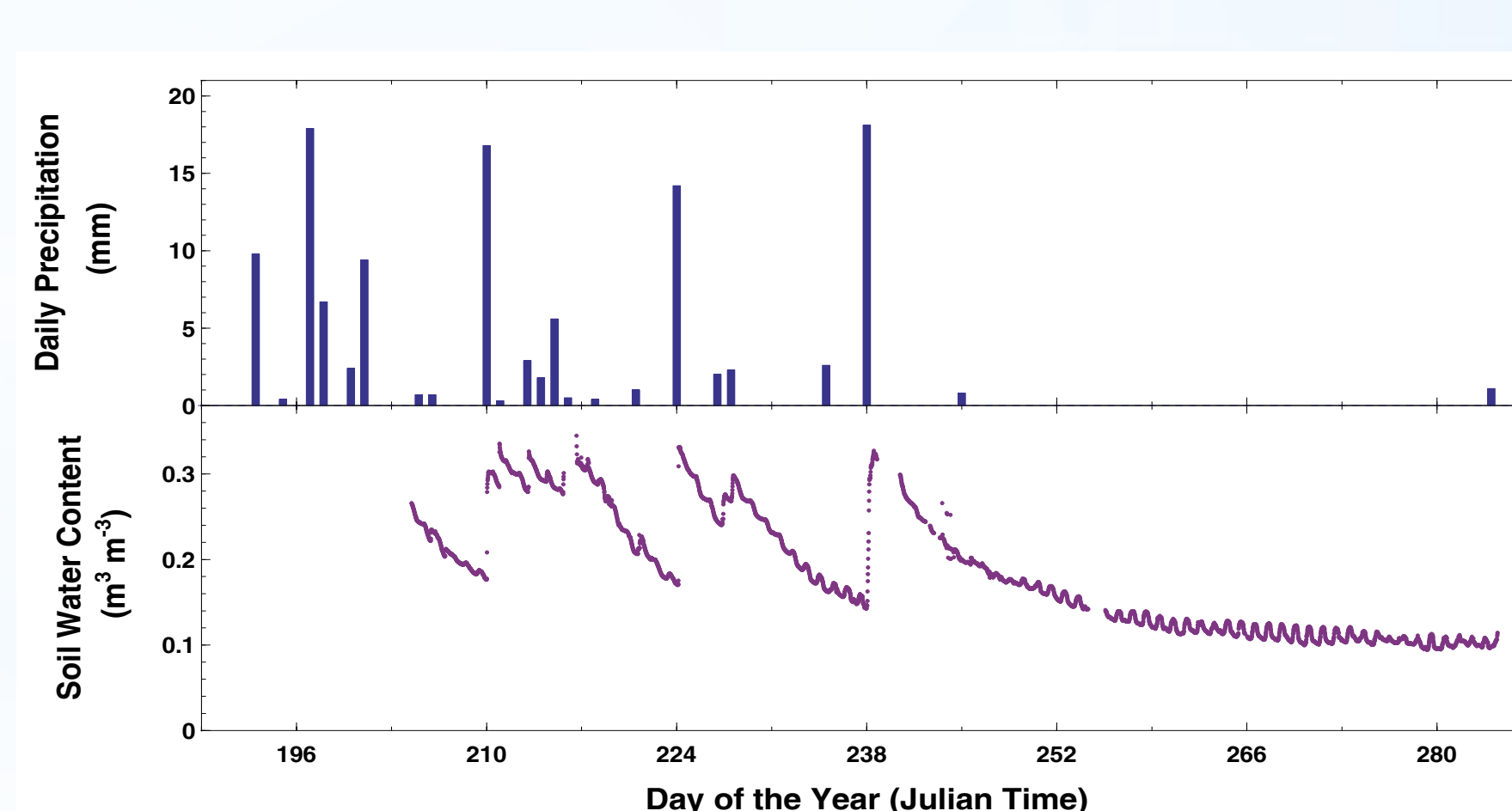
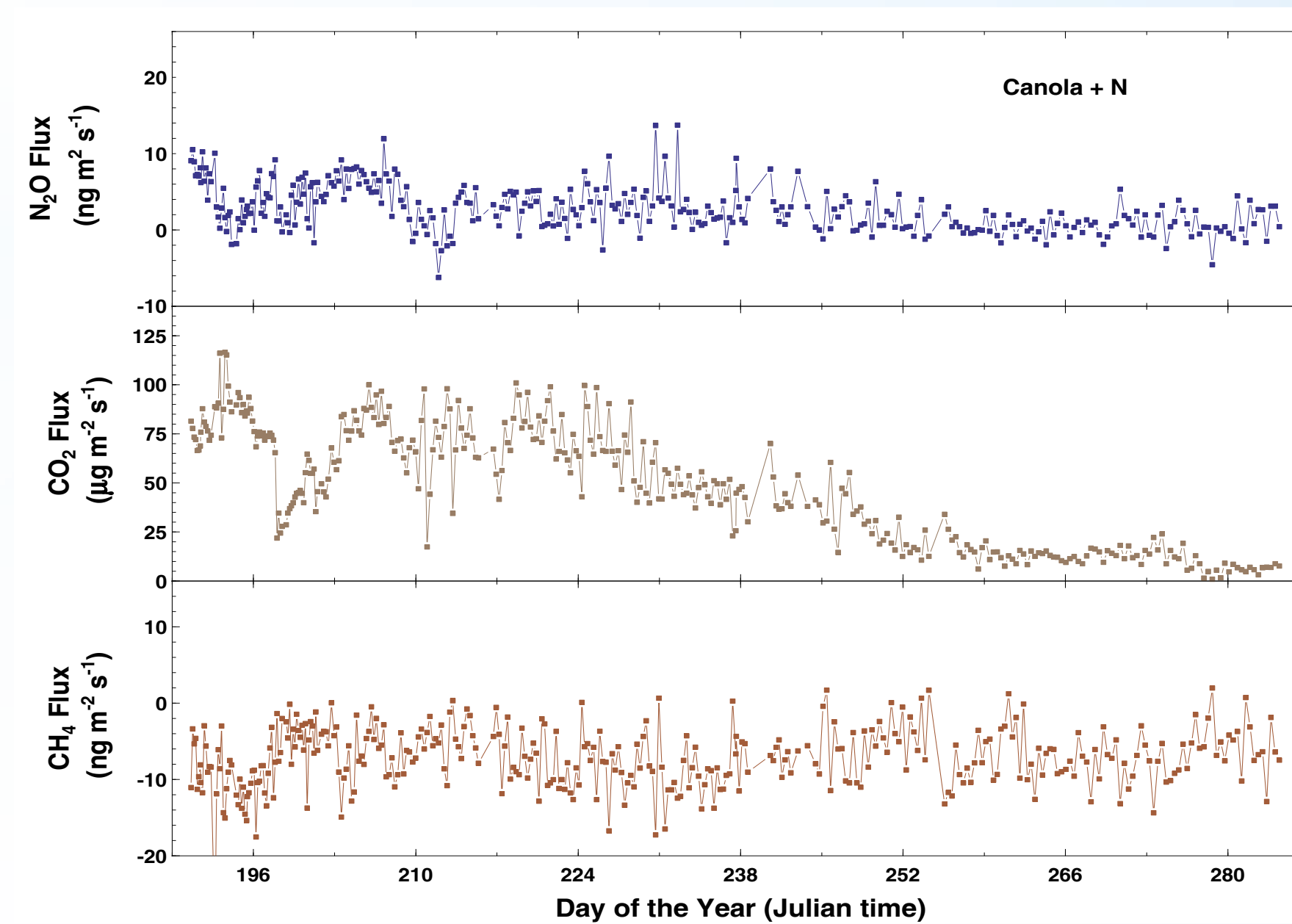


Fig 4. Daily precipitation and soil water content (@ 5 cm) were measured throughout the automated flux chamber deployment period.



Fig 5. Greenhouse gas (N₂O, CO₂ & CH₄) emissions measured with the Gasetm DX-4015 FTIR-multigas analyzer connected to a Li-Cor 8100-104 long-term flux chamber via a LI-8150-16 multiplexer.



- N₂O emissions were generally quite low, but were in the range normally encountered in Saskatchewan agricultural soils.
- CO₂ emissions exhibited a diurnal pattern (except during and immediately following a precipitation event) and decreased as both the soil temperature and water content decreased.
- CH₄ emissions generally were not observed; rather, the soil acted as a small sink for CH₄.

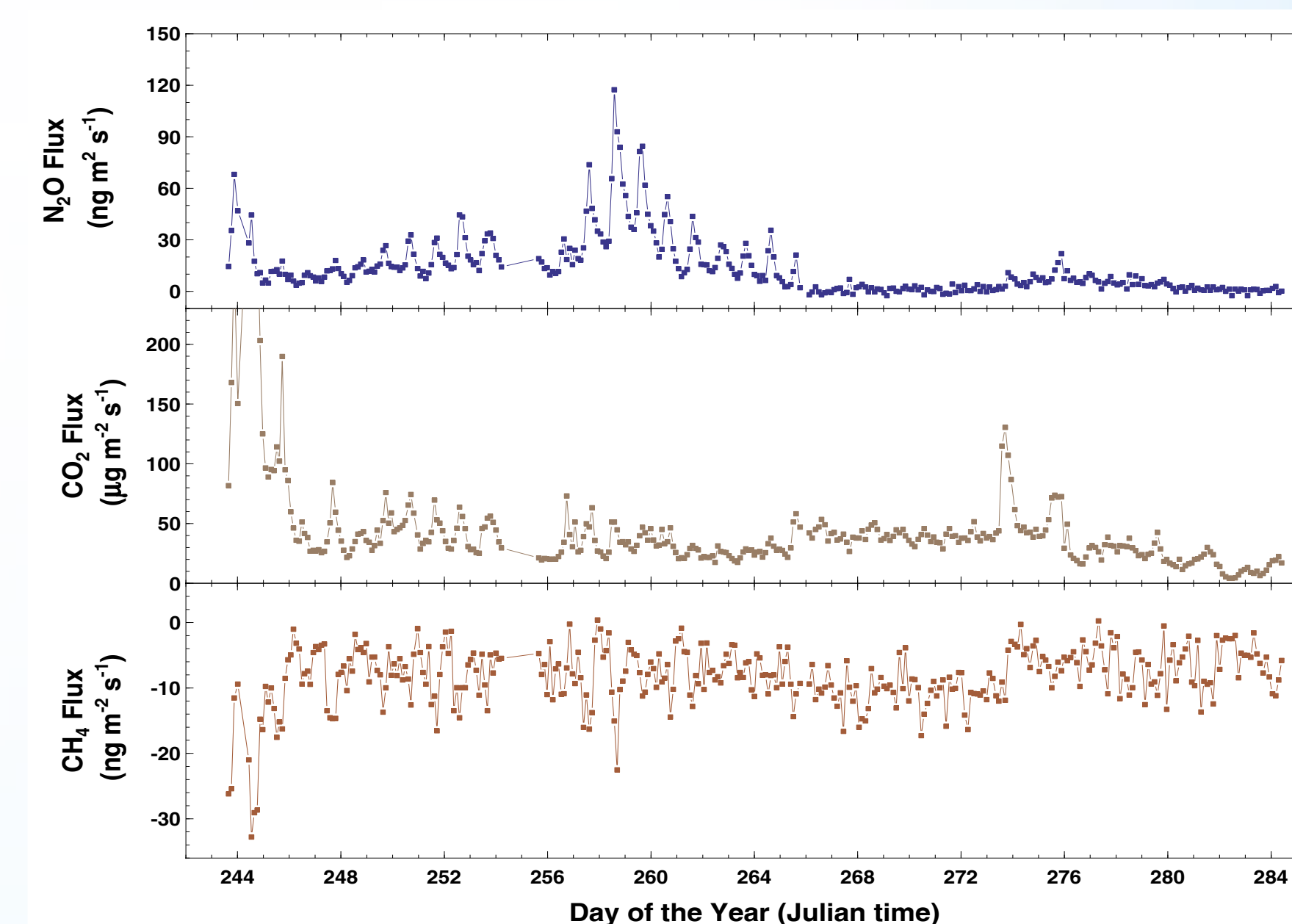


Fig 6. Greenhouse gas (N₂O, CO₂ & CH₄) emissions measured following a late-season fertilizer application.

- Soil disturbance and the application of fertilizer-N resulted in a short burst of activity, during which N₂O and CO₂ emission were significantly greater than background levels (see Fig. 5; days 242 - 284).
- Evidence of a diurnal pattern was present during periods of peak N₂O emission.

Conclusions

- The Gasetm DX-4015 FTIR multi-component gas analyzer is capable of making accurate measurements of N₂O, CO₂ and CH₄ at near-ambient concentrations.
- The accuracy and precision of the FTIR-MGA was comparable to that attainable using conventional gas chromatography.
- Increases in CO₂ concentration, from ambient to about 5-times ambient, had no significant effect on N₂O measurements over the range of N₂O concentrations normally encountered when measuring emissions from Saskatchewan agricultural soils.
- Water vapor interferences with N₂O and CO₂ measurements were generally small (i.e., <4%).

- Simultaneous measurements of N₂O, CO₂ and CH₄ emissions from soils in the field can be automated by interfacing the Gasetm FTIR-MGA with a Li-Cor multiplexer and long-term flux chambers.
- Operational and maintenance requirements of the automated soil greenhouse gas system are comparable to those of a conventional automated soil CO₂ flux measurement system.

Acknowledgements

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