Temporal Variations in Greenhouse Gas Emissions from Dairy Cow Manure

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Introduction

The implementation of air quality regulations for animal feeding operations (AFOs) increases the need for accurate determination of gas emission rates. However, there are no standardized methods for collection, measurement, and quantification of gas emissions from AFOs due to the difficulty of the measurement. Temporal variations complicate the determination of gas emissions from AFOs. The temporal variations in gas emissions primarily result from environmental variables (i.e., temperature, manure's moisture content, and porosity). Other factors influencing the temporal variations include variations of biochemical processes in manure and variations of gas transport mechanisms.

Focusing on diurnal and weekly variations, our research aims : (1) to characterize individual gas emission rates from manure as a function of temperature, moisture content, and time after excretion; (2) to investigate and determine the degree of temporal variability affected by these factors.

Experiment Design and Setup

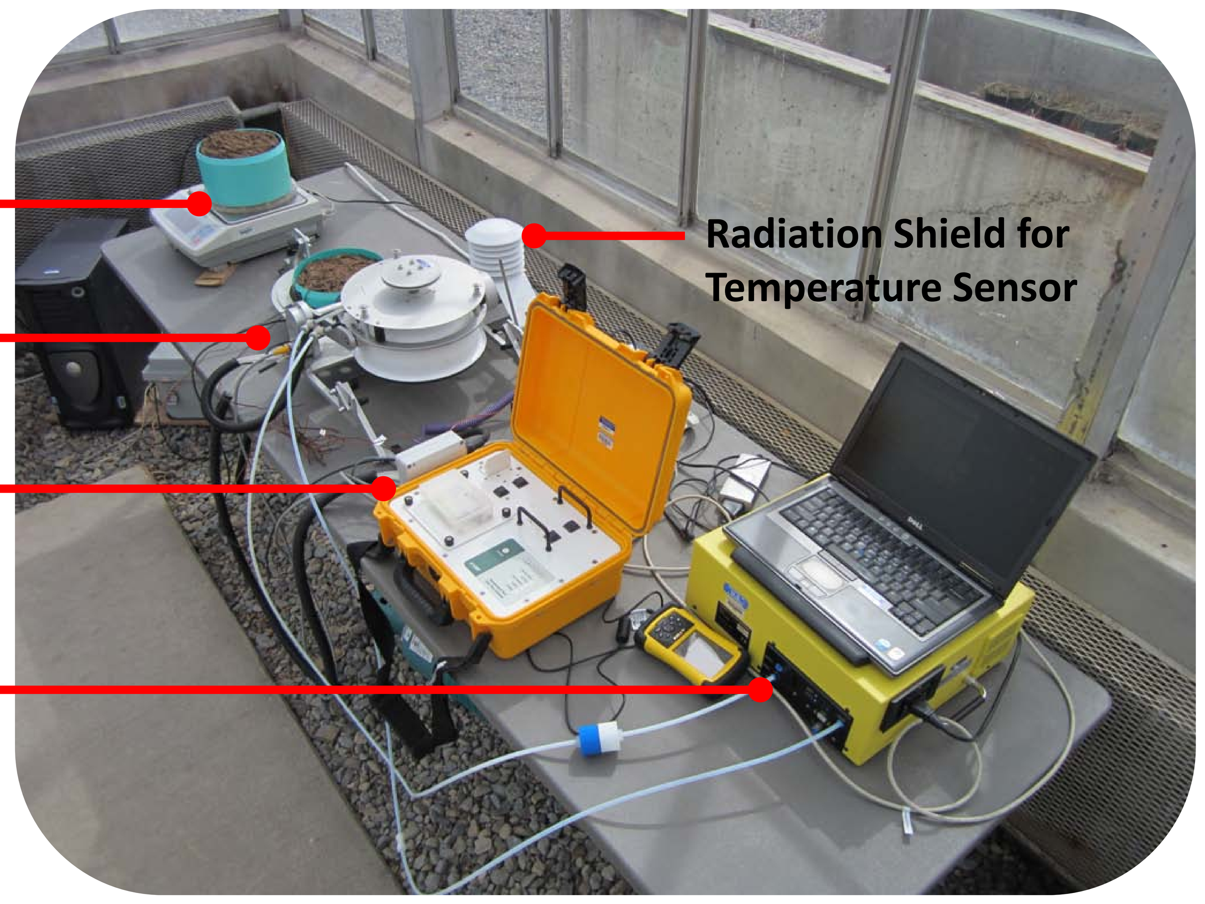
Fresh dairy cow manure samples (left) were collected from the Caine Dairy Teaching and Research Center (Wellsville, Utah). The milking cows were mature Holsteins fed a standard total mixed ration (TMR) diet with an approximate crude protein content of 17%. The chamber was programmed to be closed for three minutes (one observation), with three observations performed in one hour. The Fourier Transform Infrared Spectrometers (FTIR) gas analyzer measures 15 different gases at low concentrations including CO_2, CO, CH_4, NH_3, N_2O, NO_x, water vapor, and volatile organic compounds (VOCs).

High Resolution Balance (GX-10K, A&D Weighing, San Jose, Cal.)

Long-Term Chamber (LI-COR LI-8100-101, LI-COR Biosciences, Lincoln, Neb.)

CO_2 Gas Analyzer Unit (LI-COR LI-8100A, LI-COR Biosciences, Lincoln, Neb.)

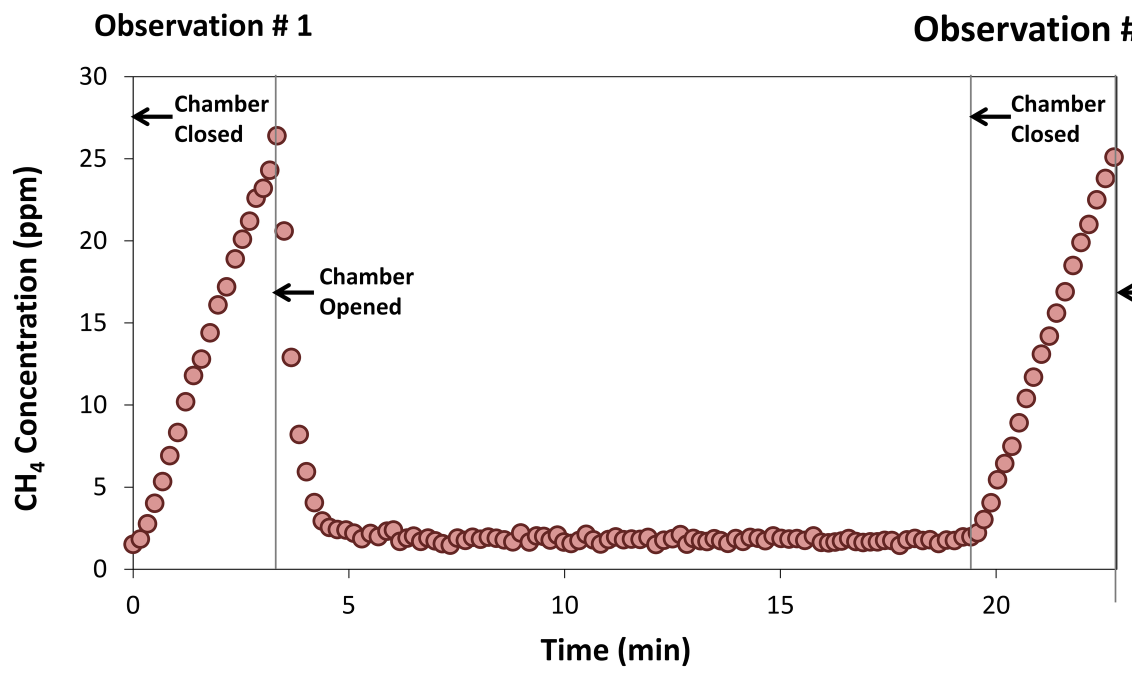
FTIR Gas Analyzer (Gasmet DX-4030, Gasmet Technologies Oy, Helsinki, Finland)



Radiation Shield for Temperature Sensor

Moisture Content Sensor (EC-5, Decagon Devices, Pullman, Wash.) was installed to monitor changes in manure moisture content during the investigation.

Closed Dynamic Chamber



Methane (CH_4) flux data were collected on dairy cow manure in a greenhouse. Two observations are shown for demonstration purposes. For both observations, the observation length (time when the chamber is sealed against manure container) was three minutes. The first data point used in the analysis is collected after the chamber touches down (below).

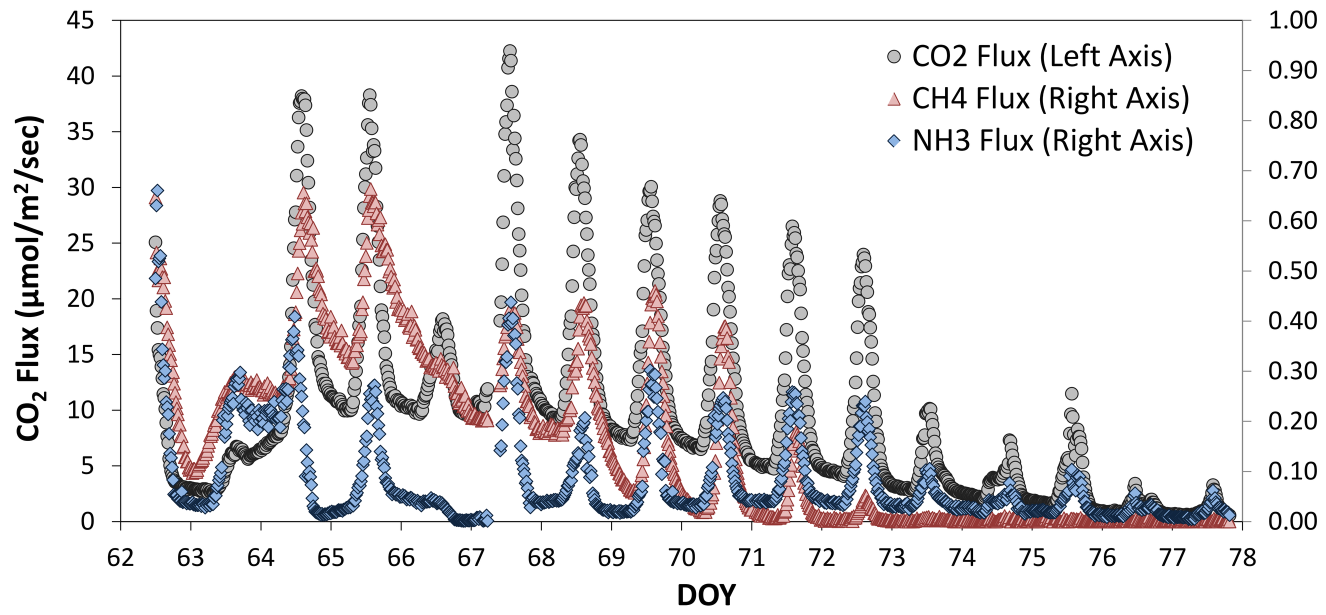
Calculating gas flux (J_g) from measured data:

$$J_g = \frac{P \cdot V}{P_S \cdot R \cdot S \cdot (273.15 + T)} \cdot \frac{\partial C}{\partial t}$$

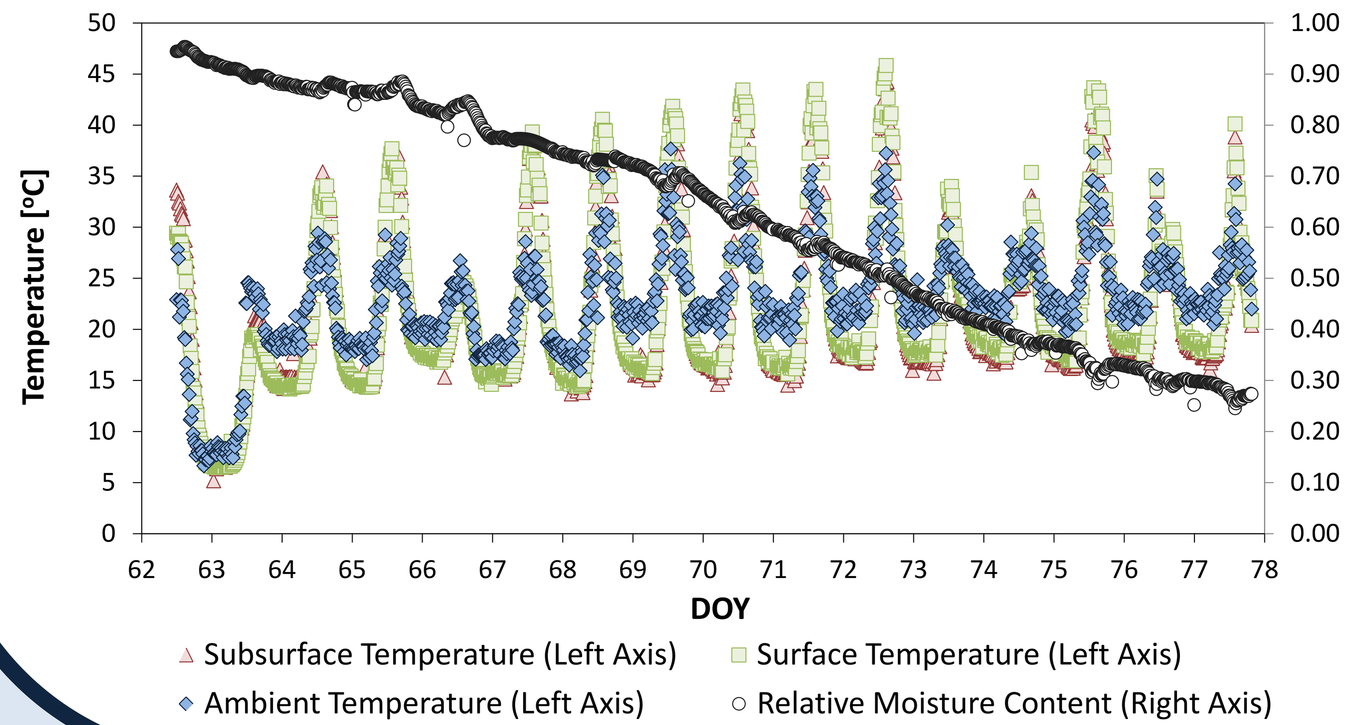
where P is the measured ambient pressure, V is the total system volume, P_s is the standard pressure, R is the gas constant, S is surface area of the chamber over the emission source, T is the temperature (°C), C is the gas concentration, and t is the observation time

Results and Discussion

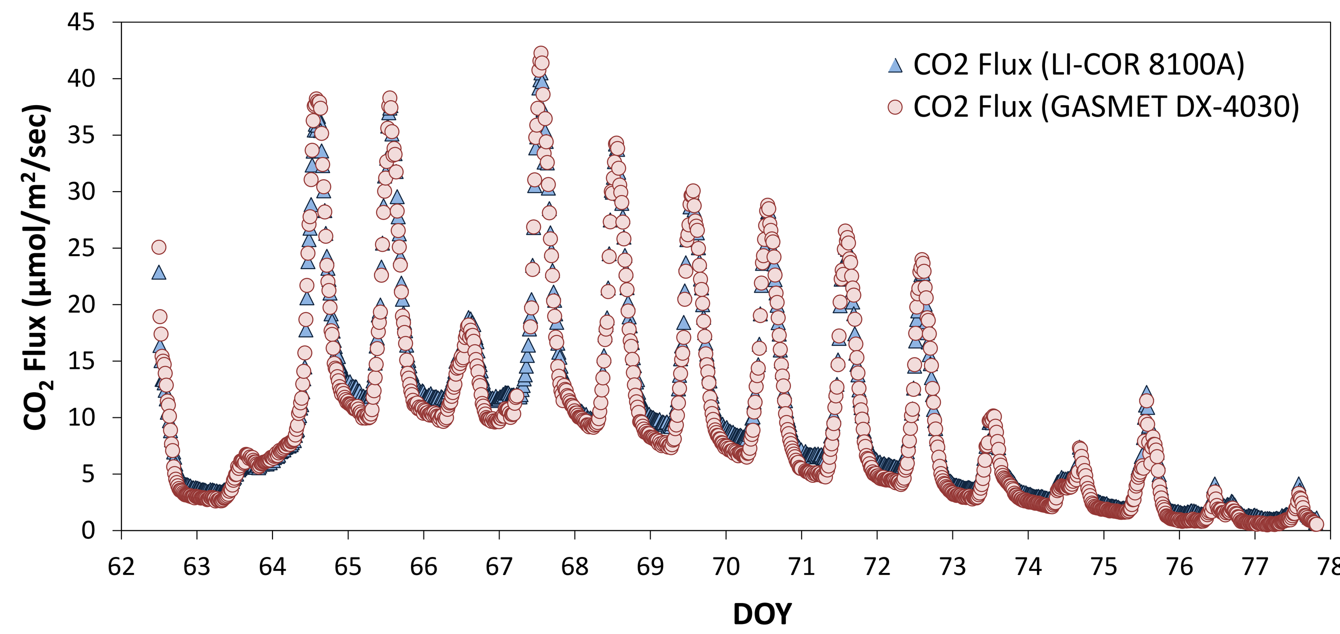
A. CO_2, CH_4, and NH_3 Fluxes



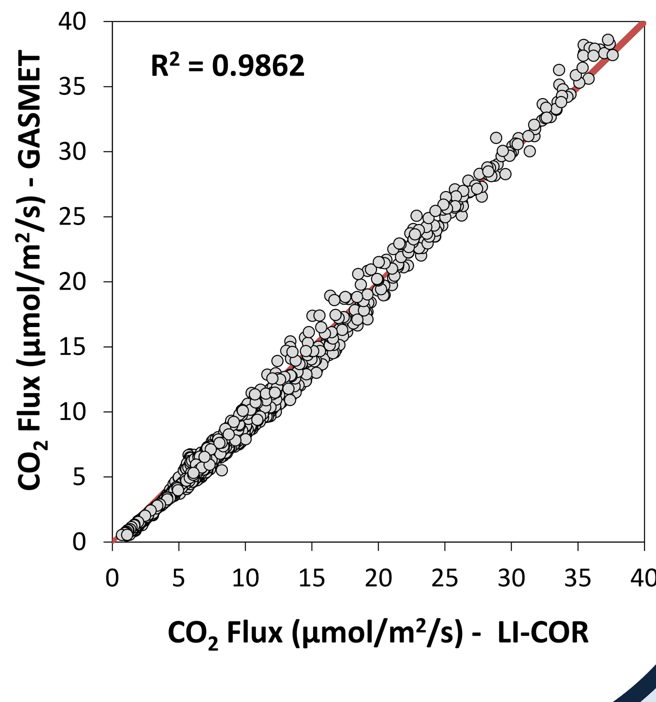
B. Temperatures and Relative Moisture Content



C. Comparison of CO_2 Fluxes between LI-COR 8100A and GASMET DX-4030



The temporal variation in gas emissions on the diurnal and weekly time scales shows a strong correlation to manure temperature and moisture content. However, under actual field conditions, abrupt increases in gas fluxes may occur in response to rainfall events. Hence, further investigation is necessary to determine the effect of rainfall events on the gas emission rates. In addition, CO_2 fluxes determined from using LI-COR 8100A and GASMET DX-4030 were in well agreement.



Acknowledgments

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