The Impacts of Changes in Snowfall on Soil Greenhouse Gas Emissions Using an Automated Chamber System

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Introduction

- The feedback effect of global warming itself impacts emissions of Greenhouse Gas (GHG) from biogenic sources such as agricultural systems.
- Snow cover has decreased in many regions of the northern hemisphere and is projected to decrease further in most. The reduced snow cover may enhance soil freezing and increase the depth of frost. The frequency of freeze-thaw cycles is likely to increase due to the reduction of snowpack thickness.
- Freeze and thaw cycles can strongly affect soil C and N dynamics. The pulses of N_2O emissions from soil after thawing have been reported in various studies. However, most studies were based on the controlled laboratory conditions or low resolution static chamber methods in situ.
- Near-continuous automated chambers provide the temporal resolution needed for capturing short-lived pulses of greenhouse gases after intermittent melting events.

Objective and Hypothesis

- **Objective:** to evaluate whether changes in snowfall increase GHG emissions, especially emissions of N_2O, from agricultural soils.
- **Hypothesis:** Decreasing snow cover will increase soil N_2O emissions throughout the winter compared with natural or enhanced snow cover because of the increasing availability of carbon and nitrate and anaerobic conditions during more frequent freeze and thaw cycles.

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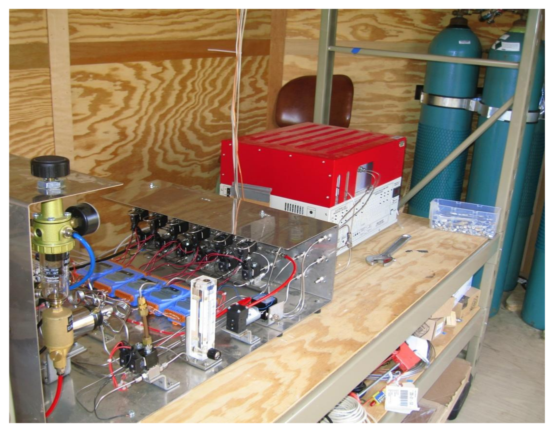
Materials and Methods

- **<u>Site Location</u> :** The Long-term Ecological Research (LTER) site at the Kellogg Biological Station in southwest Michigan. The plot was no till rotational (corn-soybean-wheat) cropland, most recently in corn.

Photo credit: Kurt Stepnitz, Michigan State University

- **<u>Experimental design and treatments:</u>** The experiment was a completely randomized design (CRD) with one factor, snow depth, with three levels, ambient, double and no snow. Each level had four replicates.

- **<u>Gas measurements and analysis:</u>**



Each chamber was sampled 4 times per day at 6 hour intervals. Samples were directly analyzed by gas chromatography in-situ. The site was equipped with dataloggers to allow in situ monitoring of soil moisture and temperature.

Results

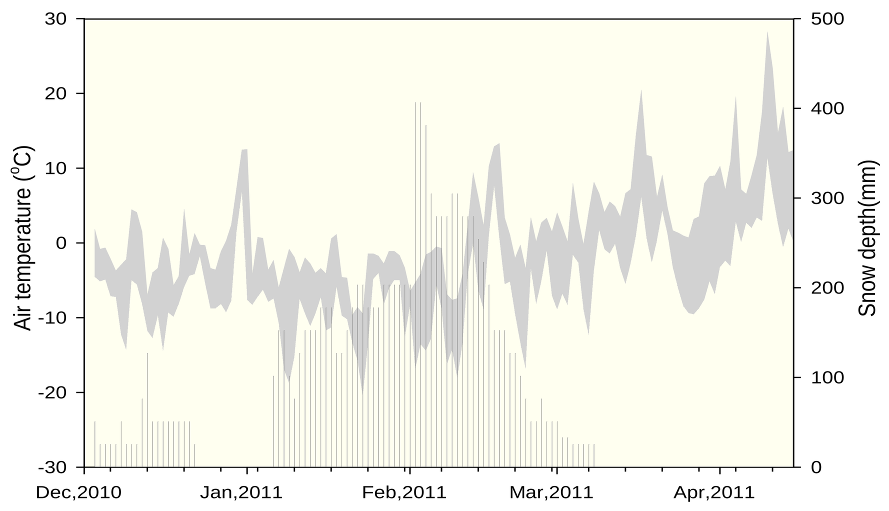


Figure 1. Air temperature (℃, minimum - maximum; continuous band) and natural snow depth (vertical bars) from December 3rd , 2010 to April 15th,2011

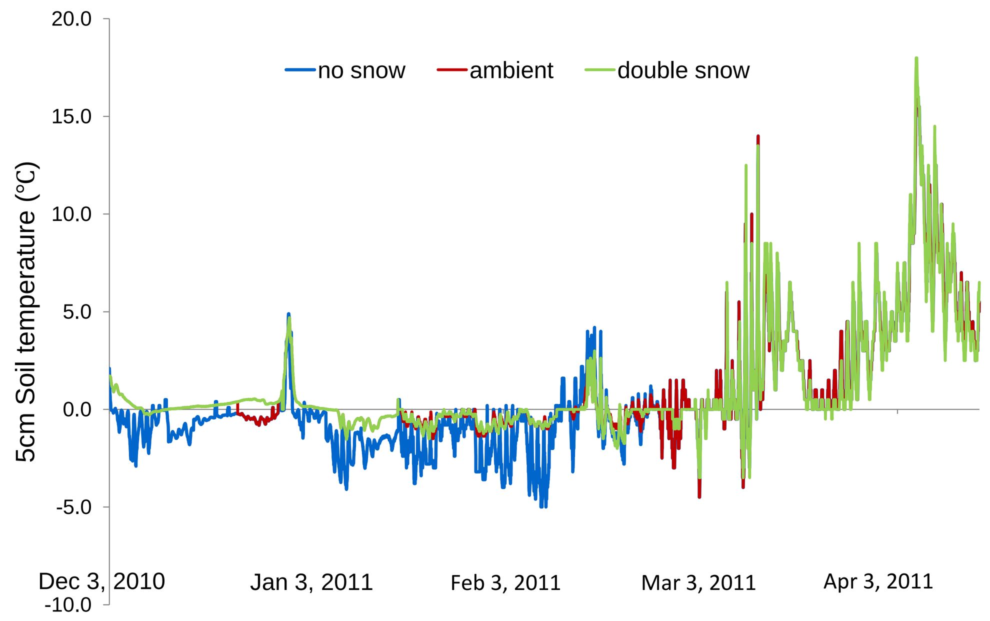


Figure 2. 5cm soil temperature in the ambient (red line), no snow (blue), and double snow depth (green) treatments from January 18th to April 15th, 2011

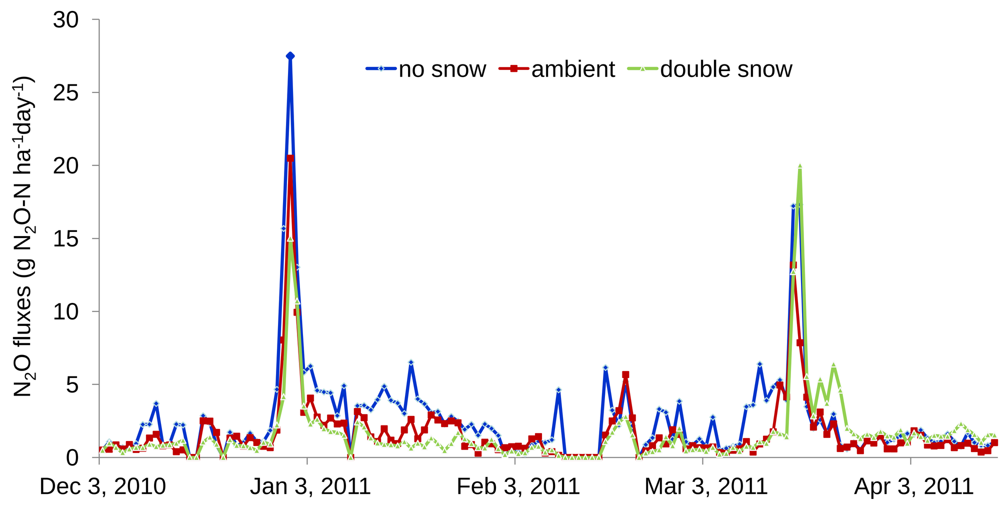


Figure 3. Daily soil N_2O fluxes from December, 2010 to April, 2011(g N_2O-N $ha^{-1}d^{-1}$) in each of the three snow depth treatments. Each point represents mean daily fluxes (4 flux measurements per chamber each day) with 4 replicate chambers per treatment. Error bars omitted for clarity.

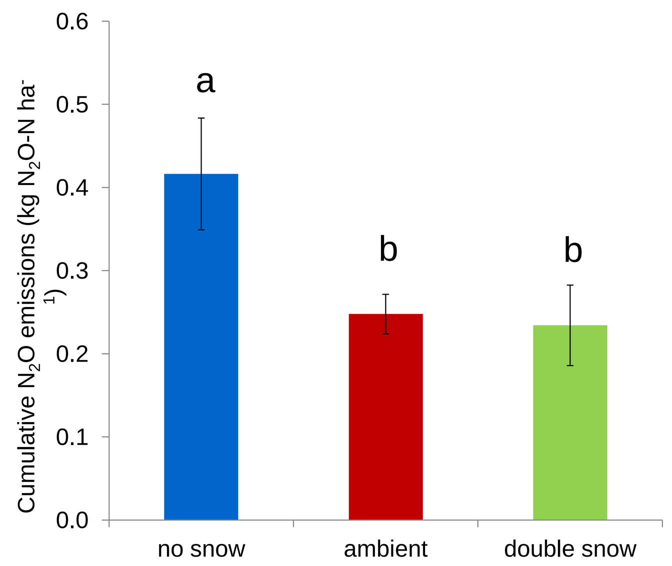


Figure 4. Cumulative N_2O fluxes from December, 2010 to April, 2011 (g N_2O-N $ha^{-1}d^{-1}$) in the three snow depth treatments. Error bars represent standard errors based on n=4 replicate chambers per treatment. The treatments marked with the same letters are not significantly different from each other (α=0.05).

Conclusions

1. There were more freeze-thaw cycles in the no snow treatment than in the ambient and double snow treatments.
2. Soil temperature at 5 cm depth was more variable in the no snow treatment than in the ambient and double snow treatments.
3. Cumulative N_2O fluxes were substantially higher in the no snow treatment than in the ambient and double snow treatments.