Effect of the Spatial Variability of Fluxes on Total Field Greenhouse Gases Emissions

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INTRODUCTION

Greenhouse gases (GHGs) are produced from natural biological processes and through human-related activities such as fossil fuel combustion and soil disturbance. GHGs found in the atmosphere absorb infrared radiation (Snyder et al., 2008), and reduce the amount of infrared radiation that is reflected back to space therefore causing an increase in the temperature on Earth. The three major GHGs linked to agriculture and its practices are CO_2, N_2O, and CH_4. Quantifying gas fluxes from field is difficult because of their spatial and temporal variability. Fluxes quantification approaches taking account the spatial variability of fluxes are therefore needed. The objective of these study was to compare two methods for estimating of total greenhouse gas fluxes from soil in a corn and a soybean. The two methods compared were the Traditional Approach (TA) and GIS Approach (GIS).

METHODS

Study area/soils: Freeman Farm in Jefferson City, MO on a Waldron silty clay soil (*Aeric Fluvaquents*).

Sample Collection: Forty-eight cylindrical polyvinylchloride (PVC) static and vented (closed) chambers measuring 0.30 m in height and 0.20 m in diameter were inserted into the soil in 48 research plots to a depth of approximately 0.05 m since June 14, 2011 (one week after planting). Individual chambers were numbered (1-48) and placed near the center of each respective plot. Soil air samples for gas analysis were collected as follows: (*1*) the two chamber ventilation holes were sealed off by rubber stoppers; (*2*) the greased chamber lids were secured atop the chamber, (*3*) the chamber was allowed to fill up with soil air for thirty minutes, (*4*) and the air samples were collected with a 60 ml syringe and stored in a 200 ml Tedlar bag. The concentration (ppm) of each greenhouse gas was measured using a Shimadzu (GC-2014) gas chromatograph with an Electron Capture Detector (ECD). The data was then transferred into an Excel data sheet where the gas concentrations were converted to a flux value (e.g. mg C-CO_2 m-2 h-1). Simple statistics of emission values were used to calculate total field emissions using TA and GIS approaches.

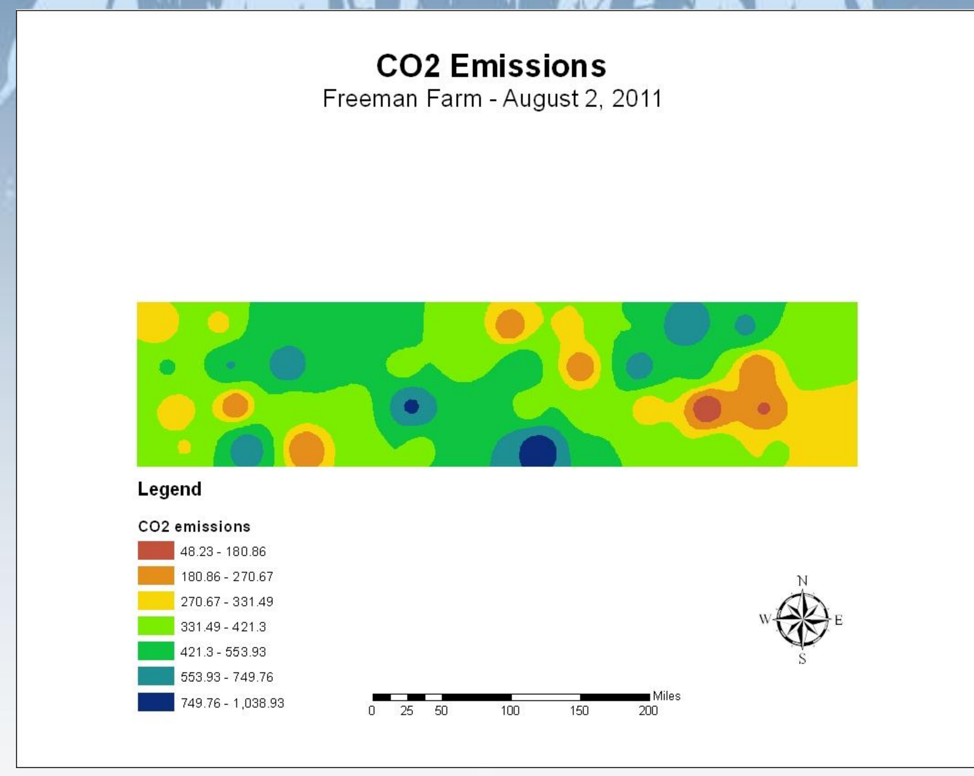
<u>Traditional Approach:</u>

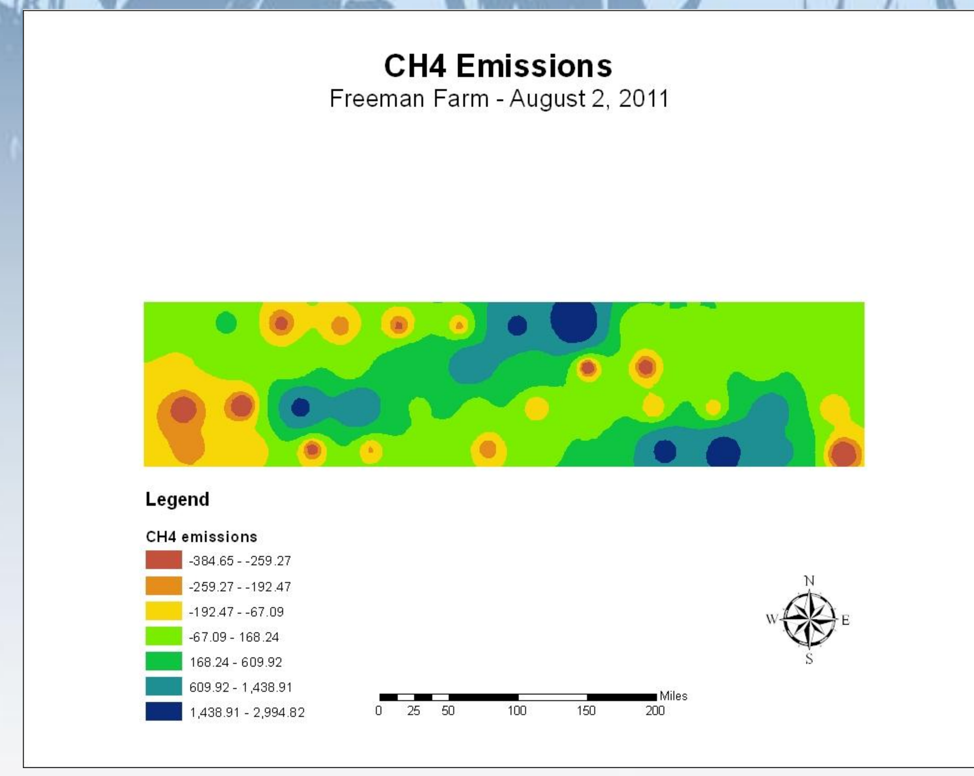
Multiplying the plot area (12,486.168 $m^{2)}$ by the minimum flux value to calculate the total minimum field flux. The same steps are required to calculate the total maximum field flux.

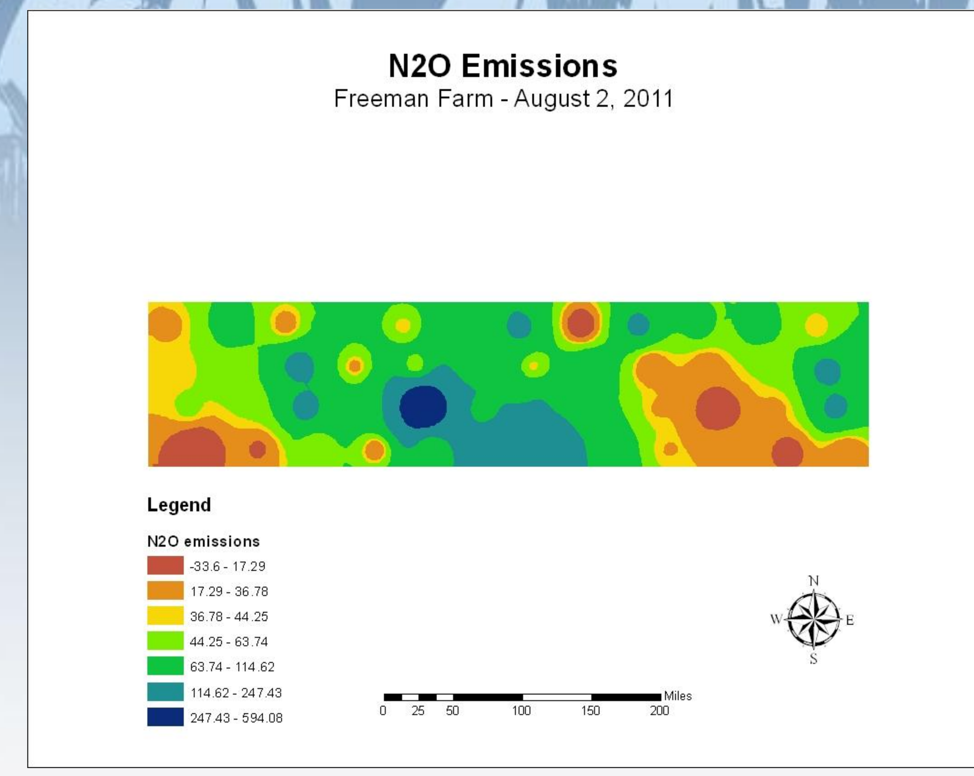
<u>GIS Approach:</u>

Produce interpolated maps based on gas concentrations collected from each chamber, dividing concentrations into classes. Multispec 3.2 software using the maximum likelihood method to identify concentration classes and calculate their respective area (m^2). The class area is then multiplied by the minimum flux value for the intended gas to generate the total minimum flux for the area. The total minimum fluxes for each area are combined to equal the total minimum flux for the field. The same steps are required to calculate total maximum field flux (mg for CO_2, µg for CH_4 and N_2O).

RESULTS







Figures 1-3. GIS total field flux of CO_2, CH_4, and N_2O: August 30, 2011.

Table 1. Total Flux of CO_2 fluxes : August 2, 2011: GIS Approach

Class	Min Flux (mg C-CO_2 m^{-2} h^{-1})	Max Flux (mg C-CO_2 m^{-2} h^{-1})	Area (%)	Area (m^2)	Total Min (mg C-CO_2 m^{-2} h^{-1})	Total Max (mg C-CO_2 m^{-2} h^{-1})
1	48.23	180.86	0.6	74.92	3613.25	13549.49
2	180.86	270.67	5.76	719.20	130075.10	194666.75
3	270.67	331.49	15.09	1884.16	509986.33	624581.11
4	331.49	421.3	40.23	5023.19	1665135.72	2116268.00
5	421.3	553.93	30.9	3858.23	1625470.58	2137187.08
6	553.93	749.76	6.42	801.61	444036.93	601016.60
7	749.76	103893	1	124.86	93616.29	129722.55
Total			100	12486.17	4471934.20	5816991.58

Table 2. Total Flux of CH_4 fluxes : August 2, 2011: GIS Approach

Class	Min Flux (µg C-CH_4 m^{-2} h^{-1})	Max Flux (µg C-CH_4 m^{-2} h^{-1})	Area (%)	Area (m^2)	Total Min (µg C-CH_4 m^{-2} h^{-1})	Total Max (µg C-CH_4 m^{-2} h^{-1})
1	-384.65	-259.27	1.3	162.32	-62436.46	-42084.75
2	-259.27	-192.47	4	499.45	-129491.55	-96128.51
3	-192.47	-67.09	14.2	1773.04	-341256.21	-118952.98
4	-67.09	168.24	46	5743.64	-385340.63	966309.54
5	168.24	609.92	19	2372.37	399127.85	1446957.08
6	609.92	1438.91	12.6	1573.26	959561.01	2263775.47
7	1438.91	2994.82	2.9	362.10	521027.69	1084420.94
Total			100	12486.17	961191.71	5504296.79

Table 3. Total Flux of N_2O fluxes : August 2, 2011: GIS Approach

Class	Min Flux (µg N-N_2O m^{-2} h^{-1})	Max Flux (µg N-N_2O m^{-2} h^{-1})	Area (%)	Area (m^2)	Total Min (µg N-N_2O m^{-2} h^{-1})	Total Max (µg N-N_2O m^{-2} h^{-1})
1	-33.6	17.29	3.8	474.47	-15942.34	8203.66
2	17.29	36.78	28.3	3533.59	61095.69	129965.28
3	36.78	44.25	5.8	724.20	26635.99	32045.75
4	44.25	63.74	16	1997.79	88402.07	127338.94
5	63.74	114.62	34.7	4332.70	276166.32	496614.11
6	114.62	247.43	10.2	1273.59	145978.79	315124.16
7	247.43	594.08	1.2	149.83	37073.43	89013.39
Total			100	12486.17	619409.95	1198305.28

Table 4. Simple statistics of CO_2, CH_4, and N_2O fluxes: August 2, 2011: Calculation-Based TA

Simple Statistics	CO_2 (mg C-CO_2 m^{-2} h^{-1})	CH_4 (µg C-CH_4 m^{-2} h^{-1})	N_2O (µg N-N_2O m^{-2} h^{-1})
Minimum	48.23	-384.65	-33.60
Maximum	1038.93	2994.82	594.08
Range	990.70	3379.47	627.68

Table 5. Comparison between TA and GIS for calculating CO_2, CH_4, and N_2O: August 2, 2011

	g C-CO_2 m^{-2} h^{-1}		mg C-CH_4 m^{-2} h^{-1}		mg N-N_2O m^{-2} h^{-1}	
	TA	**GIS**	**TA**	**GIS**	**TA**	**GIS**
Minimum	602.21	4471.93	-4802.80	961.19	-419.54	619.41
Maximum	12972.25	5816.99	37393.83	5504.30	7417.78	1198.31

SUMMARY

- The Traditional approach underestimated or over estimated the minimum and maximum total gas flux concentrations consistently over the five sampled dates
- The GIS approach, although more time consuming, was more accurate in calculating total field fluxes and the location of specific fluxes
- Multiple soil air samples from each research plot would increase the accuracy of the calculated total field flux

REFERENCES

Snyder, C. S., Bruulsema, T. W., Jensen, T. L., and Fixen, P. E., 2008. Review of Greenhouse Gas Emissions from Crop Production Systems and Fertilizer Management Effects. Agriculture, Ecosystems & Environment. 133, 247-266.

This research is part of a regional collaborative project supported by the USDA-NIFA, Award No. 2011-68002-30190 "Cropping Systems Coordinated Agricultural Project (CAP): Climate Change, Mitigation, and Adaptation in Corn-based Cropping Systems"
November 2011 | www.sustainablecorn.org

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