Supplementary Materials

Effects of Drainage Water Management in a Corn–Soy Rotation on Soil N_2O and CH_4 Fluxes

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Table S1. Details of specific periods used to calculate the seasonally based annual N_2O estimates each year by treatment. Mean ± 95% CI reported.

Period Start	Period End	# days	# obs	Mean or Decay Function	Non-DWM (kg N_2O-N ha^{-1} period^{1})	DWM (kg N_2O-N ha^{-1} period^{1})
			2017 Corn			
1/1/17	4/27/17	116	3	Mean	0.4 ± 0.3	0.7 ± 0.7
4/27/17	6/5/17	39	3	Mean	1.0 ± 1.0	2.3 ± 1.1
6/5/17	8/10/17	66	4	Decay	2.0 ± 0.9	2.5 ± 1.4
8/10/17	1/1/18	144	4	Mean	0.9 ± 0.6	0.9 ± 0.7
				2017 Annual Estimate	***4.3 ± 0.8***	***6.4 ± 1.1***
			2018 Soybean			
1/1/18	5/14/18	133	2	Mean	0.7 ± 0.5	0.9 ± 0.6
5/14/18	7/11/18	58	3	Decay	0.5 ± 0.2	0.4 ± 0.1
7/11/18	1/1/19	174	2	Mean	0.0 ± 0.1	0.9 ± 0.4
				2018 Annual Estimate	***1.2 ± 0.3***	***2.1 ± 0.3***
			2019 Corn			
1/1/19	4/26/19	115	3	Mean	0.3 ± 0.2	0.8 ± 0.4
4/26/19	6/17/19	52	3	Decay	3.7 ± 2.5	4.7 ± 2.1
6/17/19	1/1/20	198	4-5	Decay	3.2 ± 4.4	2.3 ± 1.2
				2019 Annual Estimate	***7.2 ± 3.5***	***7.7 ± 1.4***

Table S2. The season period boundaries used for the CH_4 seasonally-based annual flux estimate. Mean ± SE.

Period Start	Period End	# days	# flux observations	DWM (CH_4-C kg ha^{-1} period^{-1})	Non- DWM (CH_4-C kg ha^{-1} period^{-1})
1/1/17	4/26/17	115	2	0.01 ± 0.01	0.02 ± 0.03
4/26/17	7/15/17	80	6	0.08 ± 0.09	0.10 ± 0.11
7/15/17	1/1/18	170	5	0.09 ± 0.13	0.06 ± 0.07
			2017 Annual Estimate	**0.18 ± 0.10**	**0.19 ± 0.06**

1/1/17	4/26/17	115	2	0.01 ± 0.03	0.03 ± 0.03
4/26/17	7/15/17	80	4	0.15 ± 0.18	0.09 ± 0.07
7/15/17	1/1/18	170	2	0.01 ± 0.03	0.04 ± 0.10
			2018 Annual Estimate	**0.17 ± 0.15**	**0.15 ± 0.06**
1/1/17	4/26/17	115	2	0.01 ± 0.03	0.03 ± 0.04
4/26/17	7/15/17	80	5	0.29 ± 0.84	0.08 ± 0.10
7/15/17	1/1/18	170	3	0.02 ± 0.10	0.31 ± 0.23
			2019 Annual Estimate	**0.56 ± 0.73**	**0.42 ± 0.12**

Table S3. USDA soil textural class description as derived from sand, silt, and clay fractions obtained by hydrometer method for each study plot.

	Study Plot			
	Non-DWM		**DWM**	
Depth (cm)	**A**	**B**	**C**	**D**
0-10	Loamy fine sand	loamy fine sand	loam	sandy loam
10-20	Loamy fine sand	loamy fine sand	loam	sandy loam
20-30	fine sand	fine sand	silty clay loam	sandy clay loam
30-40	fine sand	fine sand	silty clay loam	sandy loam
40-50	fine sand	fine sand	silty clay loam	loamy fine sand
50-60	loamy fine sand	fine sand	clay loam	fine sand
60-70	loamy fine sand	sandy clay loam	clay loam	fine sand
70-80	fine sand	sandy loam	loamy fine sand	loamy fine sand
80-90	fine sand	sandy loam	sandy loam	loamy fine sand
90-100	sandy loam	sandy loam	fine sand	loamy fine sand

Table S4. %C, %N, and bulk density measurements (mean ± SD) at 5 cm depth. N = 40 for %C and %N. N= 4 for BD.

	Study Plot			
	Non - DWM		**DWM**	
Variable	**A**	**B**	**C**	**D**
%C	1.37 ± 0.06	1.47 ± 0.07	2.17 ± 0.05	2.08 ± 0.07
%N	0.12 ± 0.01	0.13 ± 0.01	0.18 ± 0.00	0.17 ± 0.01
BD (g cm-3)	1.13 ± 0.03	1.17 ± 0.01	1.05 ± 0.03	1.11 ± 0.04

Table S5. Summary of minimum detectable flux (MDF) calculation methodologies and resulting percentages of measured fluxes over the MDF. The two methods show that between 70 and 90% of the flux measurements were above the detection limit, which is in broad agreement with the percentage of concentration slopes that were significantly different from zero. Two methods were used to calculate the minimum detectable flux (MDF) of the chamber design. The first method adopted by [1] used calculated CH_4 and N_2O fluxes binned at 0.01 ug m^{-2} hr^{-1} intervals and 95% confidence intervals of those fluxes. The lowest flux bin with at least 67% of the 95% confidence intervals of individual flux measurements not including zero was deemed the MDF. The second method is derived from [2] based on a method developed by [3] for use with small numbers of syringe samples but modified by [4] to account for the high frequency measurements of the Picarro G2308 instrument.

	MDF Method (µg m^{-2} hr^{-1})	
	Courtois 2019 [2]	**Verchot 1999 [1]**
CH_4-C MDF +/-	0.21	0.12
N_2O-N MDF +/-	1.2	2.5
CH_4-C > |MDF|	83%	92%
N_2O-N > |MDF|	92%	84%

Table S6. Summary of multiple linear regression results of ln N_2O flux data, showing the coefficients (columns) of the independent model variables. The full model had a residual standard error of 0.644 on 531 degrees of freedom with an $r^2 = 0.23$ and a p-value <0.001. The full model described by equation 2 in the main text is listed above the table below.

$$\ln(N_2O + 1) = (0.029 * NO_3N) + (0.021 * \text{soil temp}) + (0.056 * \text{WFPS}) - (0.001 * \text{WFPS}^2) - 1.37$$

Variable	Estimate	Std. Error	P-value
Intercept	-1.37	0.2150	<0.001
NO_3-N	0.029	0.0031	<0.001
Soil Temp	0.021	0.0041	<0.001
WFPS	0.056	0.0097	<0.001
WFPS ^ 2	-0.001	0.0001	<0.001

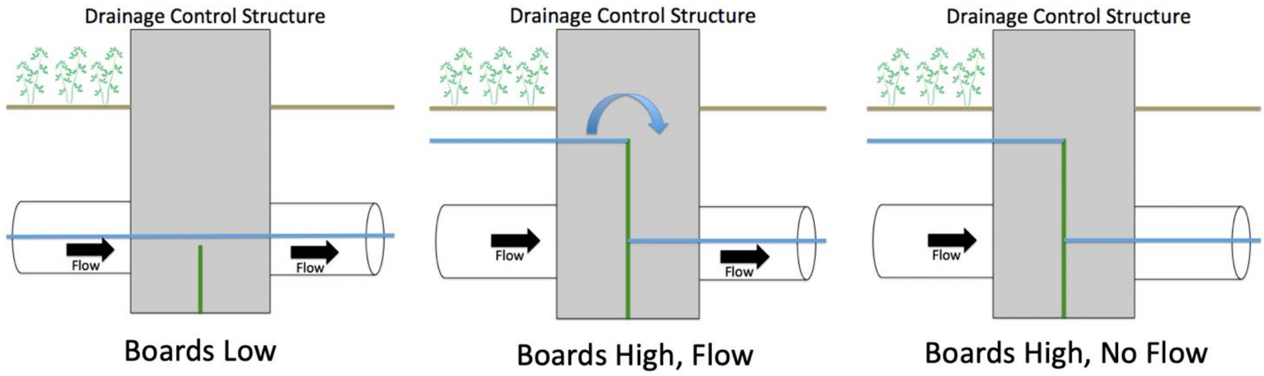

Figure S1. Detail of cross-section of drainage control structures that implements DWM. Low board and high board (green) conditions as well as theoretical water tables (blue).

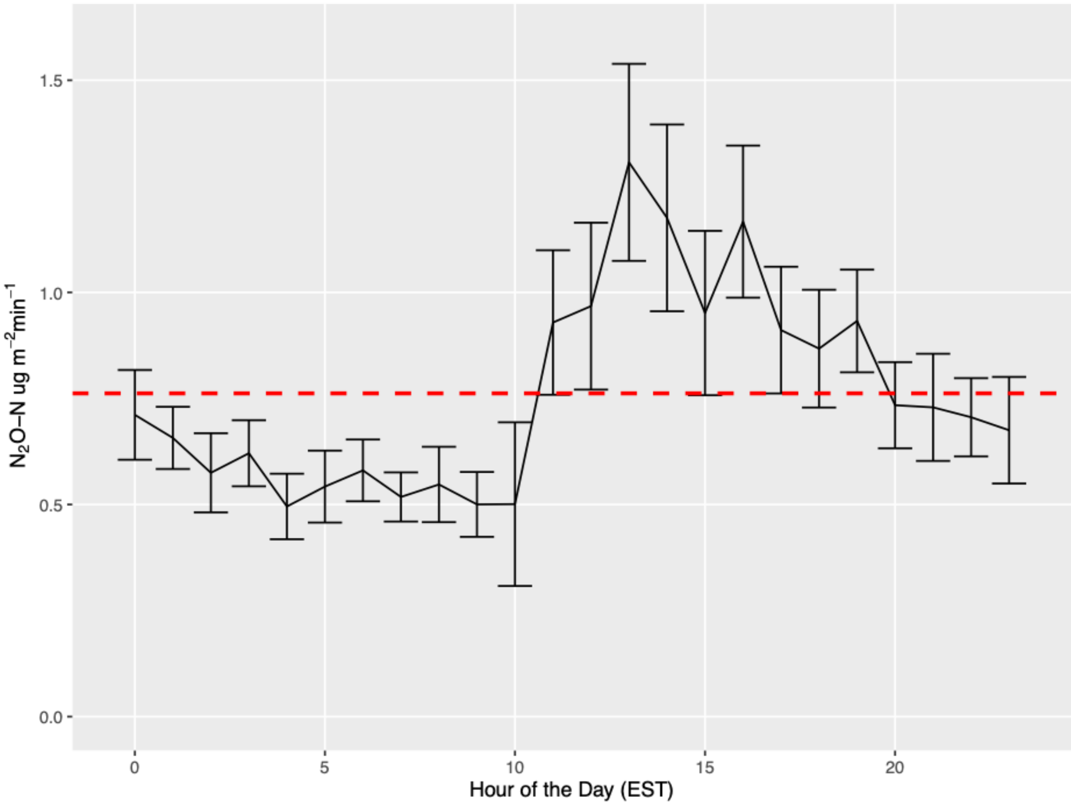

Figure S2. Summary of diel variation of N2O fluxes in a preliminary sampling campaign from 05/19/2019 to 05/22/2019 using an Eosense automated chamber. Each point is a mean (± SE error bar) from four chambers over four days for each hour of the day. This period did not include precipitation or N fertilization events. The red dashed line represents the mean flux of all chambers over the entire 4-day period.

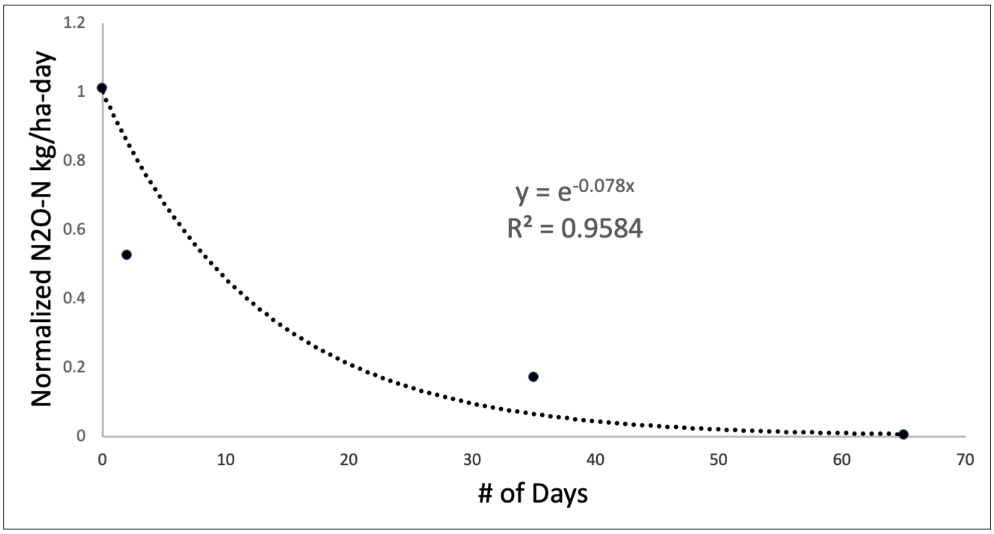

Figure S3. Demonstration of decay curve fit to a particular period of time after N fertilization to estimate annual N_2O fluxes.

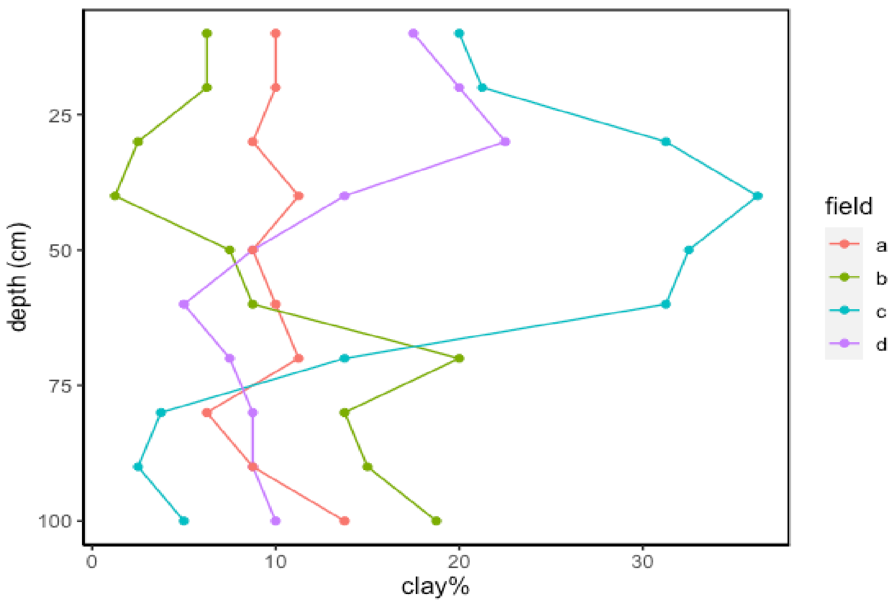

Figure S4. Clay size fraction percentage at each depth for each field.

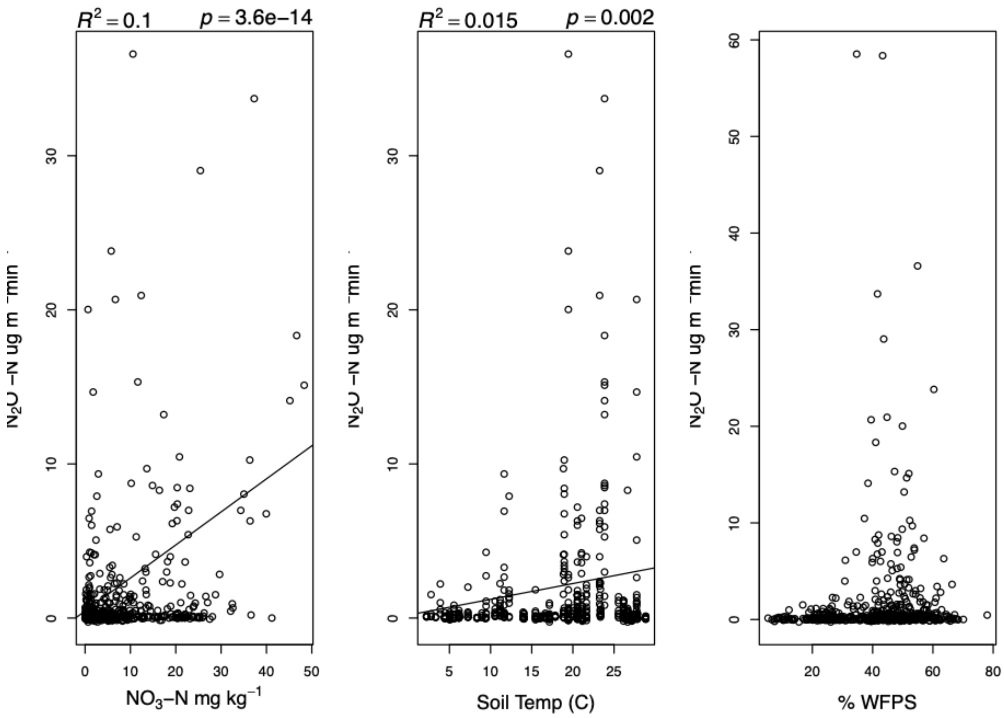

Figure S5. Three panels showing describing the individual relationships between N_2O gas fluxes and variables used in the multiple linear regression model. Linear regression p-values and r^2 values reported at the top of each panel.

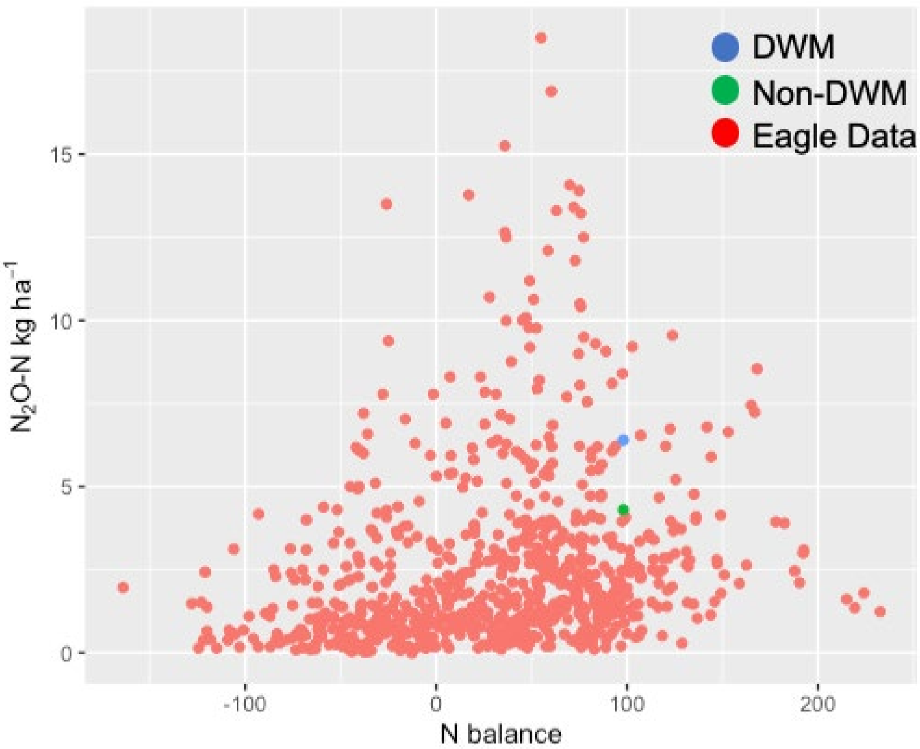

Figure S6. Comparison of study data to (61) review of studies from the U.S. cornbelt evaluating N balance versus N_2O emissions.

References

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