Investigating Impacts of Multiple Parameters on CO_2 Fluxes from a Continuous Corn Field

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INTRODUCTION

* Most of the previous studies focused on one or two parameters influencing CO_2 fluxes from croplands. Little is known about analysis of CO_2 fluxes using multiple parameters because of difficult measurements of all parameters.
* The DAYCENT model provides a useful tool to simulate these parameters. However, its performance strongly depends on how well it is calibrated and validated via local conditions.

OBJECTIVES

* Conduct systematic analysis of impacts of multiple parameters on CO_2 fluxes from a continuous corn (*Zea mays L.*) land.
* Predict CO_2 fluxes at this study site.

MATERIALS AND METHODS

* The study site is near Lennox, South Dakota. The CO_2 fluxes, soil temperature and moisture in 2008, 2009, and 2011 were measured using LI-8100A Automated Soil CO_2 Flux System.
* An improved methodology, combining PEST model and "Trial and Error" method, was used to calibrate and validate DAYCENT model
* The calibrated DAYCENT model was used to simulate five parameters: aglivc, NPP, som1c, wfps, and NH4. The Semi-log linear model was built using the ten variables (**Table 1**) for analyzing impacts of multiple parameters on CO_2 fluxes. Further, the DAYCENT model was used to predict CO_2 fluxes using the future weather data predicted by ten climate models.

Table 1. Variables in Semi-log regression model

Var	Type	Unit	Description
CO2	num	$g\ m^{-2}\ d^{-1}$	CO2 fluxes from corn field
tem	num	°C avg d^{-1}	Air temperature
prcp	num	cm d^{-1}	Precipitation
Tsoil	num	°C avg d^{-1}	Soil temperature in soil (5cm)
Msoil	num	$cm^3\ cm^{-3}$	Soil moisture in soil (10cm)
aglivc	num	$g\ m^{-2}$	Above ground live carbon
NPP	num	$gC\ m^{-2}d^{-1}$	Net primary productivity
som1c	num	$g\ m^{-2}d^{-1}$	Carbon in active soil organic matter
wfps	num	$cm^3\ cm^{-3}$	Water filled pore space in soil (5cm)
NH4	num	ppm	Ammonium in soil

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RESULTS

Table 2. Evaluation criteria for comparing soil CO_2 fluxes ($g\ m^{-2}\ d^{-1}$), soil temperature (°C), soil moisture ($cm^3\ cm^{-3}$), and corn yield ($Mg\ ha^{-1}$) between measured and the modeled data for calibration and validation.

Evaluation Criteria*	Calibration	Validation		
	CO_2	Soil Temperature	Moisture	Yield
R^2([0.5,1))	0.71	0.80	0.51	0.84
PBIAS((0, 15%])	1.40%	1.10%	-2.70%	1.10%
ME([0.5, 1))	0.71	0.71	0.02	-

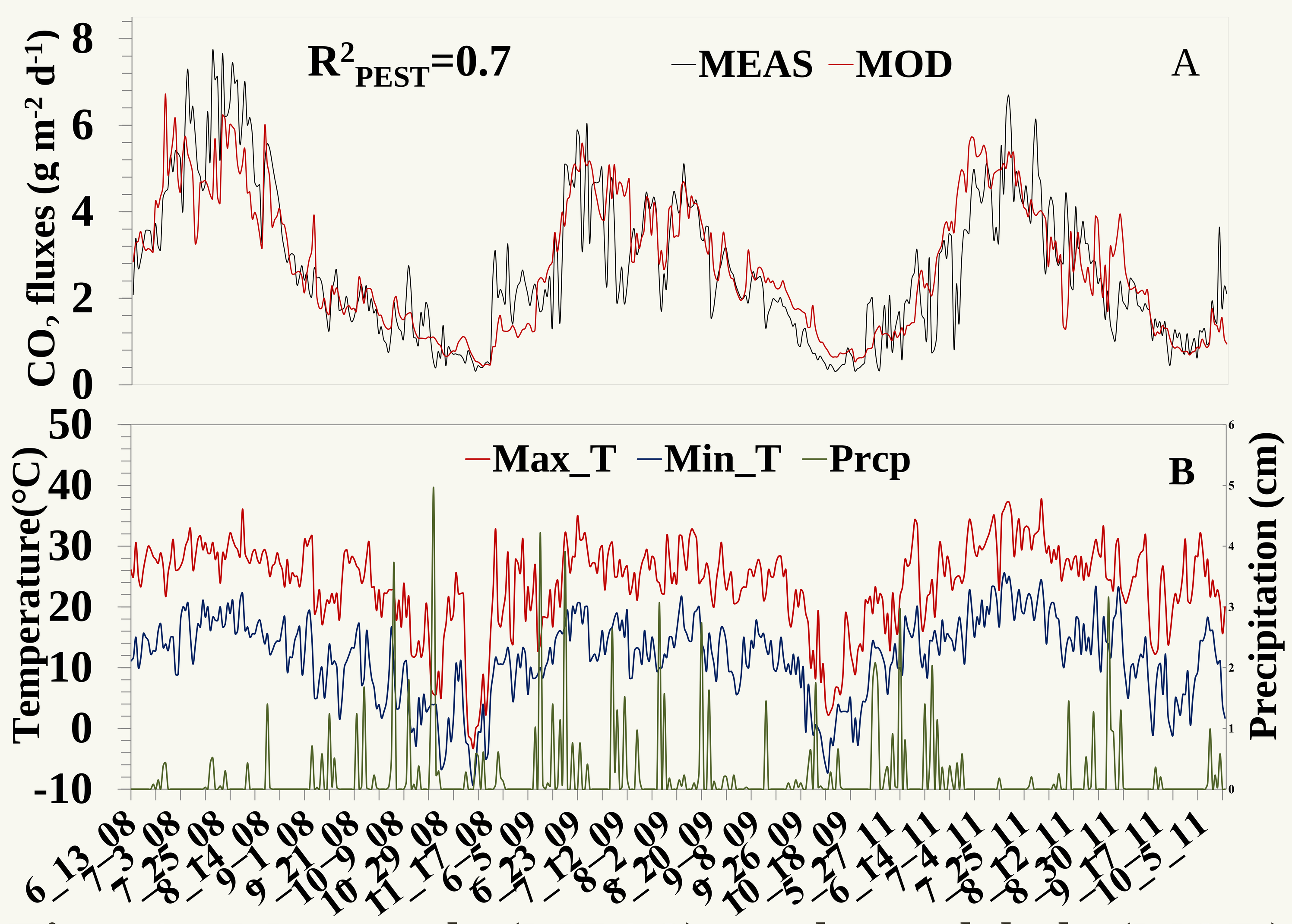

Fig. 1. Measured (MEAS) and modeled (MOD) values of CO_2 ($m^{-2}\ d^{-1}$) fluxes for the calibration period (A), and maximum (Max_T) and minimum (Min_T) temperature and precipitation (Prcp) data (B) for 2008 through 2011.

Table 3. Results of the semi-log linear model for estimating the soil surface CO_2 fluxes using different environmental variables for 2008, 2009, and 2011.

Variable	Estimate	Std-err	t-value	p-value	VIF†
Intercept	-20.06740	1.906	-10.53	<.0001	-
tem	-0.00547	0.006	-0.84	0.400	5.84
prcp	-0.12855	0.042	-3.09	0.002	1.14
lTsoil	0.94309	0.107	8.85	<.0001	4.95
lMsoil	0.44756	0.107	4.2	<.0001	2.13
aglivc	-0.00015	8.2E-05	-1.8	0.073	2.28
NPP	0.02575	0.003	8.7	<.0001	2.84
lsom1c	3.43961	0.347	9.9	<.0001	1.62
lwfps	-0.17035	0.083	-2.06	0.040	2.43
lNH_4	-0.02862	0.021	-1.36	0.174	1.51

Note: Basic information of statistical model: Dependent Variable=lCO2; Total number of observations is 442; R^2= 0.77; Adj-R^2=0.768; RMSE=1.82; p-value (>F)<0.00001 (H_0: *All Betas = 0*). The variable that its first letter is "l" was log-transformed. †VIF=Variance Inflation Factor.

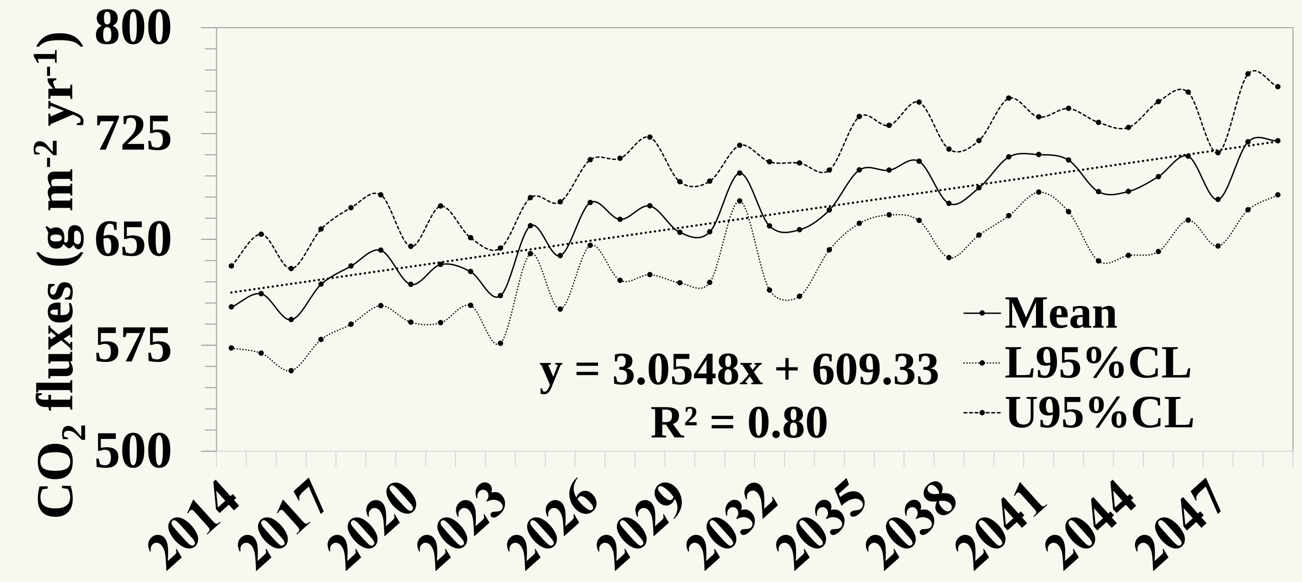

Fig. 2. Means with 95% confidence interval of forecasting CO_2 fluxes from corn land for next 36 years using the DAYCENT using weather data simulated by climate models.

* The calibrated DAYCENT model was good based on values of *R^2, PBIAS, and ME* **(Table 2)** and **Fig. 1**.
* The precipitation, soil temperature and moisture, NPP, SOM, and wfps significantly impacted soil surface CO_2 fluxes (p-value< 0.05). However, air temperature, aboveground live carbon (aglivc), and ammonium (NH4) did not impact CO_2 fluxes significantly (p> 0.05) (**Table 3**).
* The trend of means with their 95% confidence intervals on forecasting CO_2 fluxes for next 36 years increases over time with function y = 3.0548*year + 609.33 and R^2 = 0.80 (**Fig. 2**). The higher CO_2 fluxes from corn land may be due to the interactions of various parameters and parameters impacting these fluxes.

CONCLUSIONS

* The impact of multiple parameters on soil surface CO_2 fluxes is different from that of single parameter used in most of the published studies.
* All the parameters interact to emit high CO_2 fluxes in the corn land, growing larger areas of corn with increase of its sale price being a bioenergy source could result in increased CO_2 emissions.

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