CFAES

DEPARTMENT OF FOOD, AGRICULTURAL AND BIOLOGICAL ENGNINEERING

Modeling the effects of Agricultural Conservation Practices on Greenhouse Gas Emissions and Crop Yield from Corn-Soybean Systems

Garrett Steinbeck[1], Sami Khanal[1,*] , Margaret Kalcic[1], Kevin King[2]

INTRODUCTION

- **Greenhouse gas (GHG) emissions:** In the United States, agricultural accounts for more than 75% of nation's N_2O emissions. Global warming potential of N_2O is 265 times that of CO_2[1].
- **Soil carbon:** Agricultural soils make up a major repository of global labile carbon. Depending on management practices, they can be sinks or sources of CO_2.
- **Carbon trading** is one of the market-based approaches to incentivize field scale farmers in adopting practices that lower GHG emissions. These programs use national averages, which fail to capture variability of emissions amongst management practices employed [2].
- **Field scale emission quantification:**
  - **Conventional approach-** Use of field studies require expensive equipment and are time-intensive.
  - **Modeling approach:** Ecosystem models when combined with observation data can provide more reliable and cost-efficient analysis of net soil carbon and N_2O fluxes at field-and regional scale.
- **DeNitrification DeComposition (DNDC) model** is a prominent process-based biogeochemical model with global use [3].

OBJECTIVES

1. Perform statistics-oriented calibration and sensitivity analysis of the DNDC model
2. Predict the impact of incorporating winter wheat cover crop and tillage conservation practices into a corn-soybean cropping system on GHG emissions and SOC using the DNDC model

METHODS

Study site

- Field in corn-winter wheat-cover crop rotation, tile drained, with urea ammonium nitrate fertilizer and conventional till in Maumee River Watershed [4] (Fig.1)

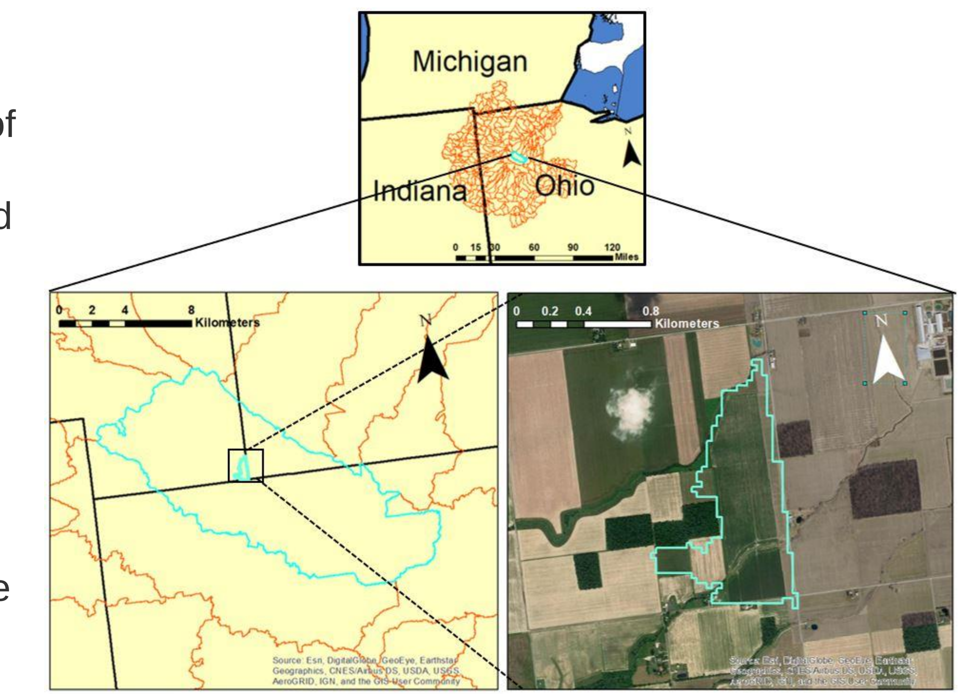

Fig. 1 *Location of study area within sub-basin of Maumee River Watershed.*

METHODS CON'T

Data

- **In-situ:** water, nitrate leaching (daily) and crop yield (annual) for years 2016-2017
- **Soil:** pH, bulk density, clay fraction, etc. from Soil Survey Geographic Database
- **Climate:** Daily max/min temperature and precipitation from National Weather Service

Modeling framework

- **PEST:** a model-independent, open source software for parameter estimation was integrated with DNDC (Fig. 2) for model calibration [5]
  - Iteratively linearizes non-linear model behavior on parameters to a set of linear equations to be solve
  - Calibration minimizes sum of weighted square residuals (SWSR) between observed data and DNDC simulated output

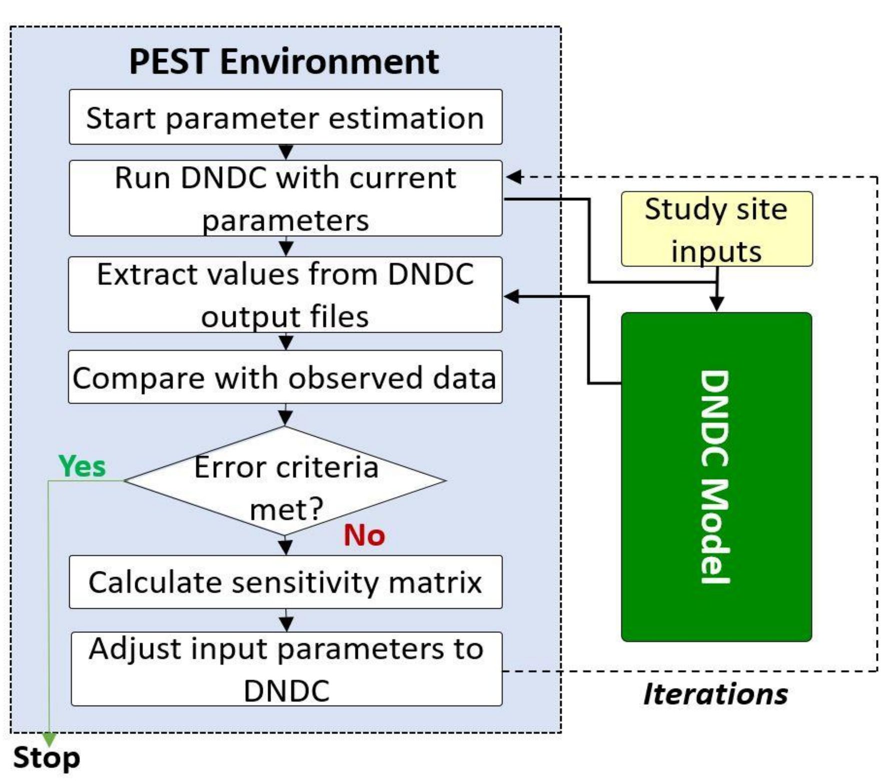

Fig. 2 *Process flow diagram of the PEST-DNDC integrated framework.*

RESULTS AND CONCULSIONS

Sensitive model parameters to water & nitrate leaching and yield	
• Crop water demand	• Soil field capacity
• Grain biomas fraction at maturity	• Thermal degree days

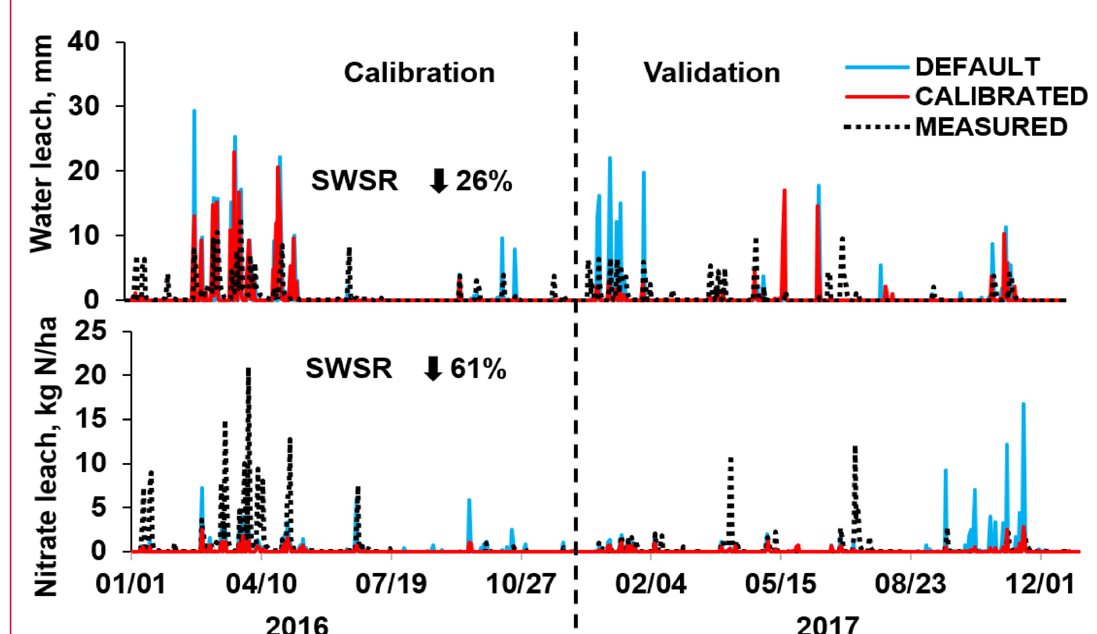

Fig. 4 *Simulated daily water and nitrate leach compared with measured data for calibration and validation years .*

Soil organic carbon long term (>10 years)	
Management Scenarios	SOC loss
CC	⬇ (green)
NCC	⬆ (red)
CT	⬆ (red)
NT	⬇ (green)

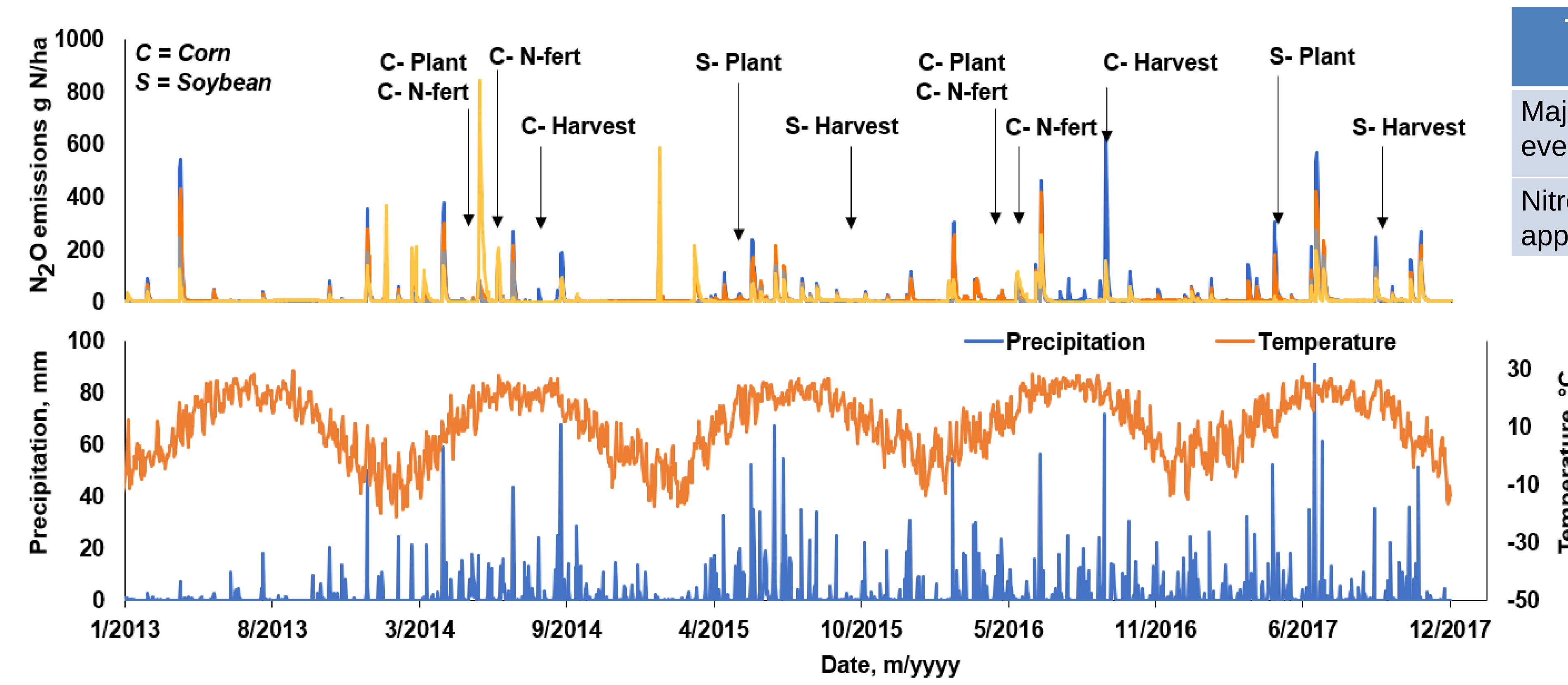

Fig. 5 *Daily nitrous oxide fluxes and climate data with management practices marked for each scenario*

Timing for Daily N_2O fluxes	
Major precipitation events	✓
Nitrogen fertilizer applications	✓

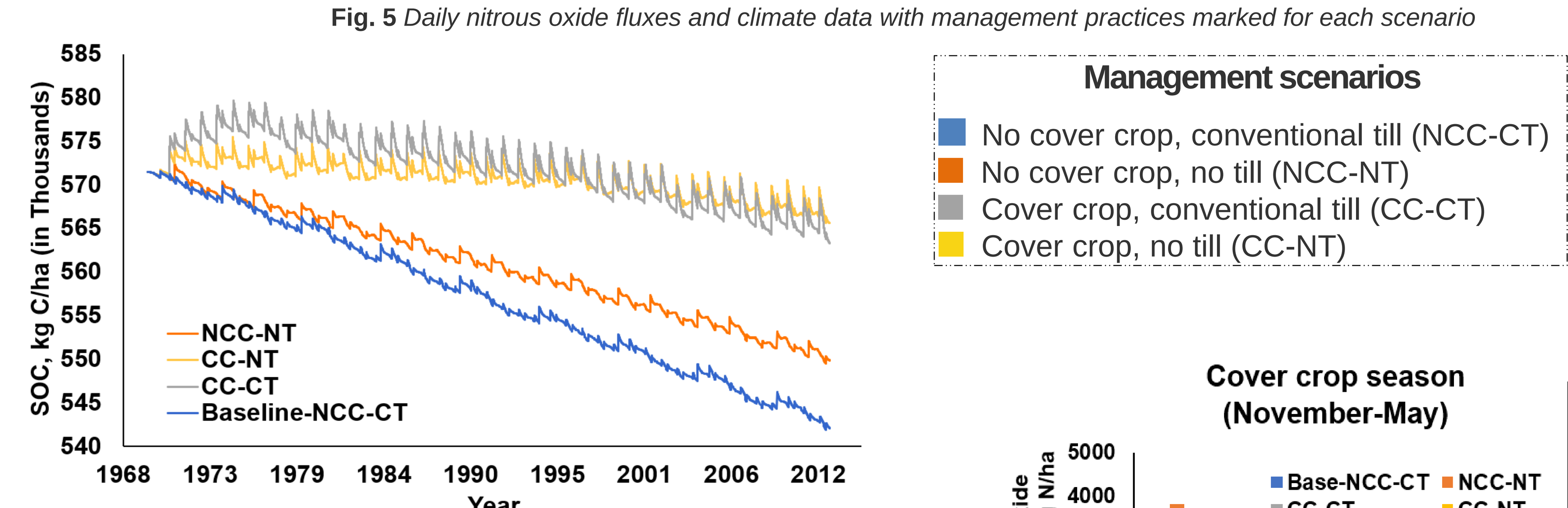

Fig. 7 *Cumulative, DNDC-simulated soil organic carbon content of soil over long term time period of over 40 years using historical climate data.*

Cover & cash crop season	
Management Scenarios	N_2O Emissions
CC	⬇ (green)
NCC	⬆ (red)
CT	⬇ (green)
NT	⬆ (red)
Cash crop season	
⬆ Precipitation	⬆ (red)

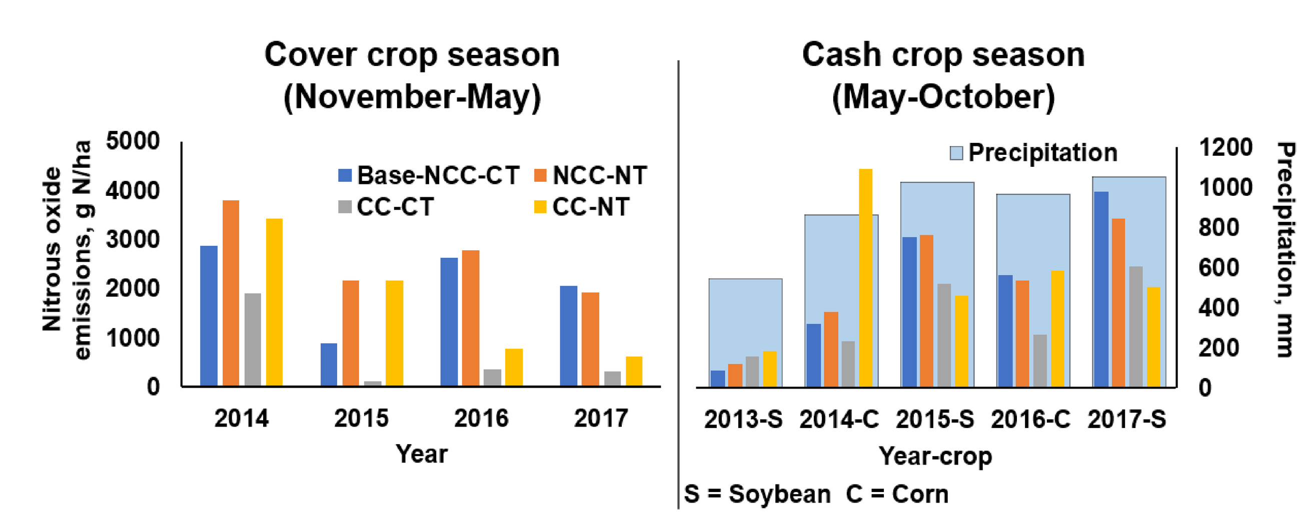

Fig. 6 *Annual and cumulative nitrous oxide emissions over cash crop and cover crop growing seasons for all scenarios.*

CONCLUSIONS AND FUTURE WORK

- **Calibration:** improved DNDC model performance and provided insight into model input-output relationships.
- **N_2O emissions:** A possible explanation for more N_2O emissions under NT conditions is increase of crop residue at the soil surface in NT compared with CT may retain more moisture, producing more anerobic soil conditions.
- **Soil carbon:** Cover crop with conservation tillage may significantly delay SOC losses, reduce N_2O over long term (>10 years).
- **Future work:** Uncertainty analysis of calibrated model simulations is needed to indicate level of confidence of predicted values.

BIBLIOGRAPHY

1. IPCC, & Core Writing Team. (2014). Climate change 2014: Synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change, 27, 408.
2. Liu, Xinyu, Kwon, Hoyoung, and Wang, Michael. GREET® Analysis for TERRA/ROOTS Success Scenarios. United States: N. p., 2019.
3. Gilhespy, S. L., et al. (2014). First 20 years of DNDC (DeNitrification DeComposition): Model evolution. Ecological Modelling, 292, 51–62.
4. Williams, M.R., King, K.W., Ford, W., Fausey, N.R., 2016. Edge-of-field research to quantify the impacts of agricultural practices on water quality in Ohio 71, 9–12.
5. Doherty, J. (2015). Calibration and Uncertainty Analysis for Complex Environmental Models. In Groundwater (Vol. 53).
6. USDA-ERS. (2011). Agricultural resource management survey.

ACKNOWLEDGEMENTS

This project was supported by fund from the United States Department of Agriculture NIFA (Award no. 2017-67021-26141 and 2019-67019-29310) and Hatch Project #NC1195

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

[1]DEPARTMENT OF FOOD, AGRICULTURAL AND BIOLOGICALENGNINEERING

[2]USDA–ARS, Columbus, OH

*Corresponding author: khanal.3@osu.edu