Validation of DAYCENT Model on N_2O Emission from Crop Rotations in Wisconsin

Maciej Kazula, Joe Lauer, Thierno Diallo
University of Wisconsin-Madison

INTRODUCTION

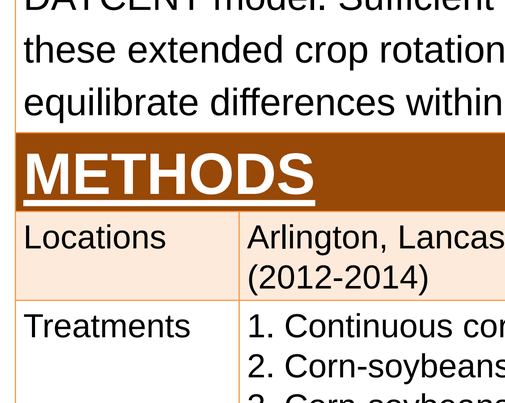
In the USA, agricultural soils account for almost 70 percent of the total nitrous oxide (N_2O) emissions mainly from N fertilizers and other soil management practices. Unlike nitrogen fertilizer and tillage management practices, crop rotation effects are often overlooked by farmers in relation to N_2O emission. Precise estimation of N_2O emission from soils is difficult to obtain because it requires continuous and at large-scale monitoring. DAYCENT (1,2) is one of the most prominent biogeochemical models capable of simulating many different environmental processes including greenhouse gases emission and crop productivity. The model is currently used by USEPA to estimate an annual N_2O emissions from agricultural lands. A number of management practices such as tillage, rotation etc. have been incorporated into the model to assess their impacts on the environment. However, generated model predictions should be validated against data measured in a field.

Our objective was to compare measured N_2O emission from six rotation treatments at three locations in Wisconsin with the predicted emissions obtained by DAYCENT model. Sufficient time has passed to allow these extended crop rotations experiments to equilibrate differences within treatments.

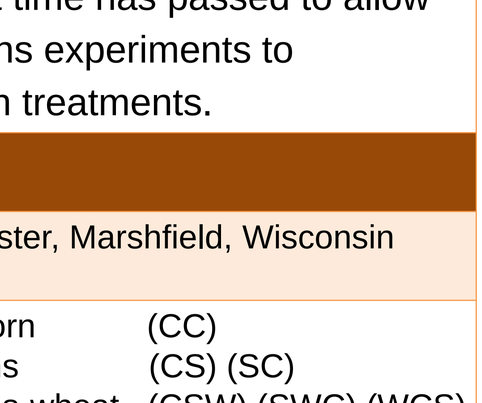
METHODS

Locations	Arlington, Lancaster, Marshfield, Wisconsin (2012-2014)
Treatments	1. Continuous corn (CC) 2. Corn-soybeans (CS) (SC) 3. Corn-soybeans-wheat (CSW) (SWC) (WCS)
DAYCENT Required Data	
Meteorology Data	Daily min/max temperature & precipitation for each specified location
Soil data	Soil texture, bulk density, field capacity, wilting point, SOM, pH
Management	Day of year and amount or intensity for events such as fertilization etc
Plant Data	Specifying a crop cultivar from the “crop.100” file or create a new one

Fig.1. The conceptual diagram illustrating the flows between different pools in DAYCENT.



Pic.1. Measuring N_2O emission.



N_2O emissions

Fig.2. Measured and predicted by DAYCENT cumulative N_2O emission of six treatments at Arlington Research Station (2012-2014).

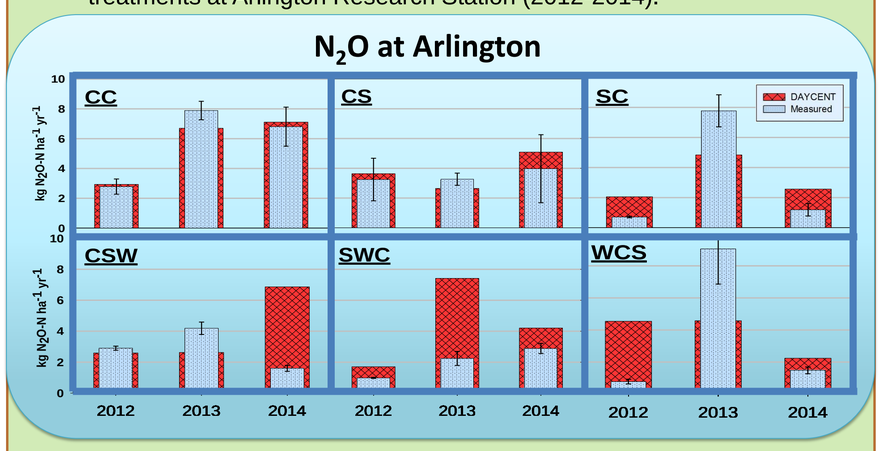


Fig.3. Measured and predicted by DAYCENT cumulative N_2O emission of six treatments at Lancaster Research Station (2012-2014).

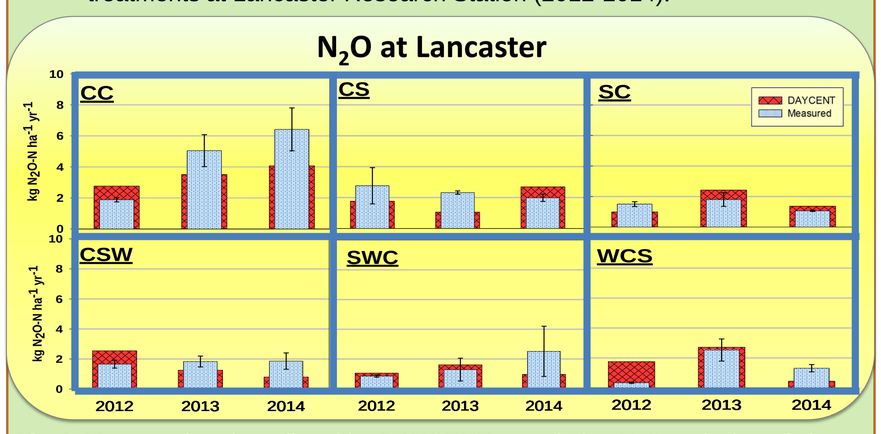
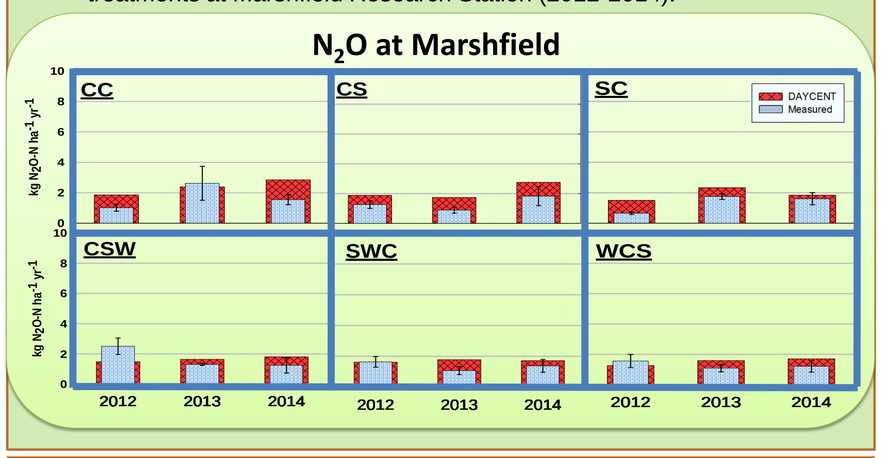


Fig.4. Measured and predicted by DAYCENT cumulative N_2O emission of six treatments at Marshfield Research Station (2012-2014).



Calibration Examples

Fig.5. Measured and predicted by DAYCENT crop yield of corn-soybean wheat rotation at three experimental stations between 2004-2014.

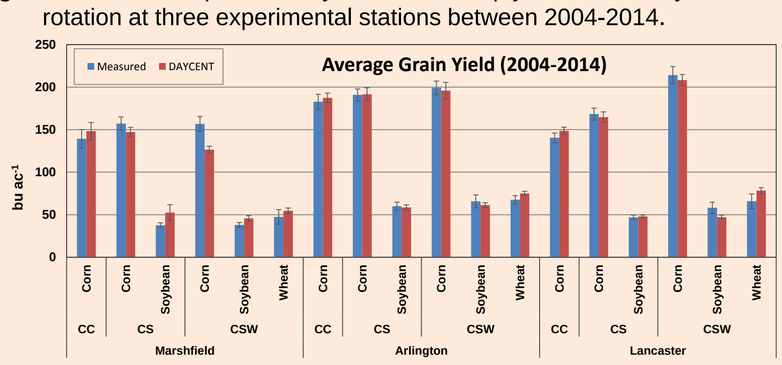


Fig.6. Measured and predicted by DAYCENT N_2O emission of wheat phase of corn-soybean-wheat rotation at Marshfield.

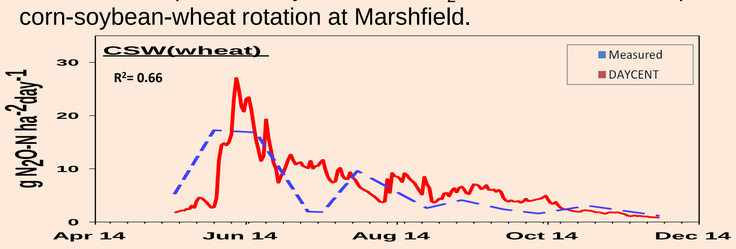
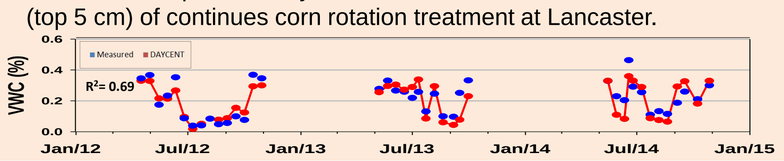


Fig.7. Measured and predicted by DAYCENT volumetric water content (top 5 cm) of continues corn rotation treatment at Lancaster.



CONCLUSIONS

In general, field measurements of N_2O emission were in agreement with the emissions predicted by DAYCENT.

Currently, DAYCENT model overpredicts N_2O emission of winter wheat at Arlington which could be mostly due to higher N fertilizer rate at this location.

Across locations, CC rotation had significantly higher N_2O emissions than CS and CSW rotations, which was mostly attributed to higher total N fertilizer and biomass inputs.

Similar to other research (3,4), N_2O emissions were highly controlled by weather and nitrogen fertilizer inputs resulting in different emissions between years.

DAYCENT model predictions for crop yields, soil moistures and soil temperatures agree with the measured data at all locations (not all data shown).

Pic.2. Corn-soybean-wheat rotation study at Arlington, WI.

RECOMENDATIONS

1) To reduce N_2O emissions the corn-soybean rotation or the corn-soybean-wheat rotation are better than continuous corn and equally effective.
2) N_2O emissions can be mitigated by improved weather prediction and N application methods that increase N use efficiency such as split-applications of N, and N-stabilizers.

Upcoming: Validated DAYCENT model is currently being used to simulate future crop rotation behaviors under different climate change scenarios.

REFERENCES

1) Parton, W.J., M. Hartman, D.S. Ojima, and D.S. Schimel. 1998. DAYCENT: Its land surface submodel: Description and testing. Global Planet. Change 19:35–48.
2) Kelly, R.H., W.J. Parton, M.D. Hartman, L.K. Stretch, D.S. Ojima, and D.S. Schimel. 2000. Intra and interannual variability of ecosystem processes in shortgrass steppe. J. Geophys. Res. 105:20.
3) Omonode, R.A., D.R. Smith, A. Gál and T.J. Vyn. 2011. Soil nitrous oxide emissions in corn following three decades of tillage and rotation treatments. Soil Sci. Soc. Am. J. 75:152-163.
4) Almaraz, J.J., F. Mabood, X. Zhou, C. Madramootoo, P. Rochette, B.L. Ma and D.L. Smith. 2009. Carbon dioxide and nitrous oxide fluxes in corn grown under two tillage systems in southwestern quebec. Soil Sci. Soc. Am. J. 73:113-119.

WISCONSIN UNIVERSITY OF WISCONSIN–MADISON

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” sustainablecorn.org

SUSTAINABLE CORN.ORG
CROPS, CLIMATE, CULTURE AND CHANGE

USDA
United States Department of Agriculture
National Institute of Food and Agriculture