

# Agricultural Soil Erosion and Carbon Cycle Observations in Iowa: Gaps Threaten Climate Mitigating Policies



National Aeronautics and Space Administration  
Experimental Program to Stimulate Competitive Research



## Introduction

In Iowa, projected climate shifts coupled with intense agriculture activities create a challenging set of questions and choices for scientists, policy makers, farmers, and businesses.

Motivated by these challenges and opportunities, our NASA EPSCoR program will focus on the links between intense agriculture, climatic shifts, CO<sub>2</sub> emissions, and Soil Organic Carbon (SOC) dynamics.



## Objectives

- To investigate the impacts that Land Use/ Land Cover (LU/LC) has on SOC sequestration potential and provide more accurate estimates of projected CO<sub>2</sub> emissions in the Midwest.
- To further NASA earth science priorities by improving the understanding of how soil and atmospheric measurements at local and regional scales can improve the biogeochemical models used for NASA forecasts of CO<sub>2</sub>, land cover, and climate at decade-to-century time scales.
- To build research capacity within Iowa and the Midwest for quantifying the links between agriculture, climate, SOC and CO<sub>2</sub> while establishing a program of national stature for carbon cycle studies in intense agricultural systems.

## Methodology

A two-pronged, methodological approach (bottom-up, top-down) was developed to investigate the impacts of LU/LC:

**Bottom-up** approach provides understanding of the relationship between LU/LC and CO<sub>2</sub>.

**Top-down** approach provides understanding of the carbon cycle at multiple spatial and temporal scales.

- Test the development of methods and models (e.g., WEPP and CENTURY) for carbon budgets at smaller scales, which will eventually be applied at larger extents to identify areas of improvement for the larger scale models.
- Produce infrastructure, partnerships, and a collection of unique data for elucidating the role of LU/LC on carbon losses and gains in intense agricultural environments for achieving sustainable extramural funding for continued research and student training.

## Outreach & Education



- Our team, with support from our collaborators at the Leopold Center, conducted an interactive exhibit at the 2011 Iowa State Fair.
- Visitors improved their understanding of the carbon cycle by conducting simple experiments measuring CO<sub>2</sub> emissions from different pots of soil that represented various agricultural tillage practices.

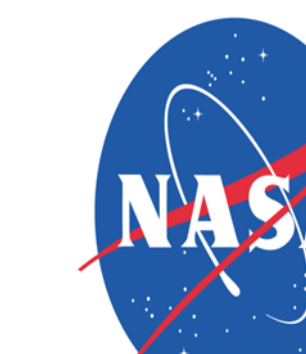
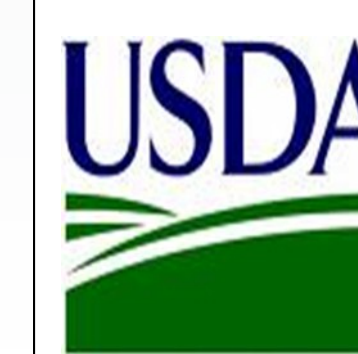


- A short movie is being developed from our collaborators from the Leopold Center, from the video series "On the Ground".
- This video showcases the on-going research being conducted by faculty and students for this project.

## EPSCoR Team

**Management PI:** Ramanathan Sugumaran, University of Northern Iowa (UNI)

**Science PI:** Thanos Papanicolaou, The University of Iowa



### Research Team:

- Charles Stanier, The University of Iowa
- Greg Carmichael, The University of Iowa
- Lee Burras, Iowa State University
- Jerry DeWitt, Leopold Center for Sustainable Agriculture
- Jeri Neal, Leopold Center for Sustainable Agriculture
- Jerry Hatfield, USDA-ARS National Lab for Agriculture & Environment
- Cindy Cambardella, USDA-ARS National Lab for Agriculture & Environment
- Christopher Wilson, The University of Iowa

### Collaborators:

- Jon Hempel, USDA-NRCS National Soil Survey Center
- Ramakrishna Nemani, NASA Ames Research Center
- G. James Collatz, NASA Goddard Research Center
- Ali Tokay, NASA Goddard Research Center

### Student Involvement:

#### Graduate (6):

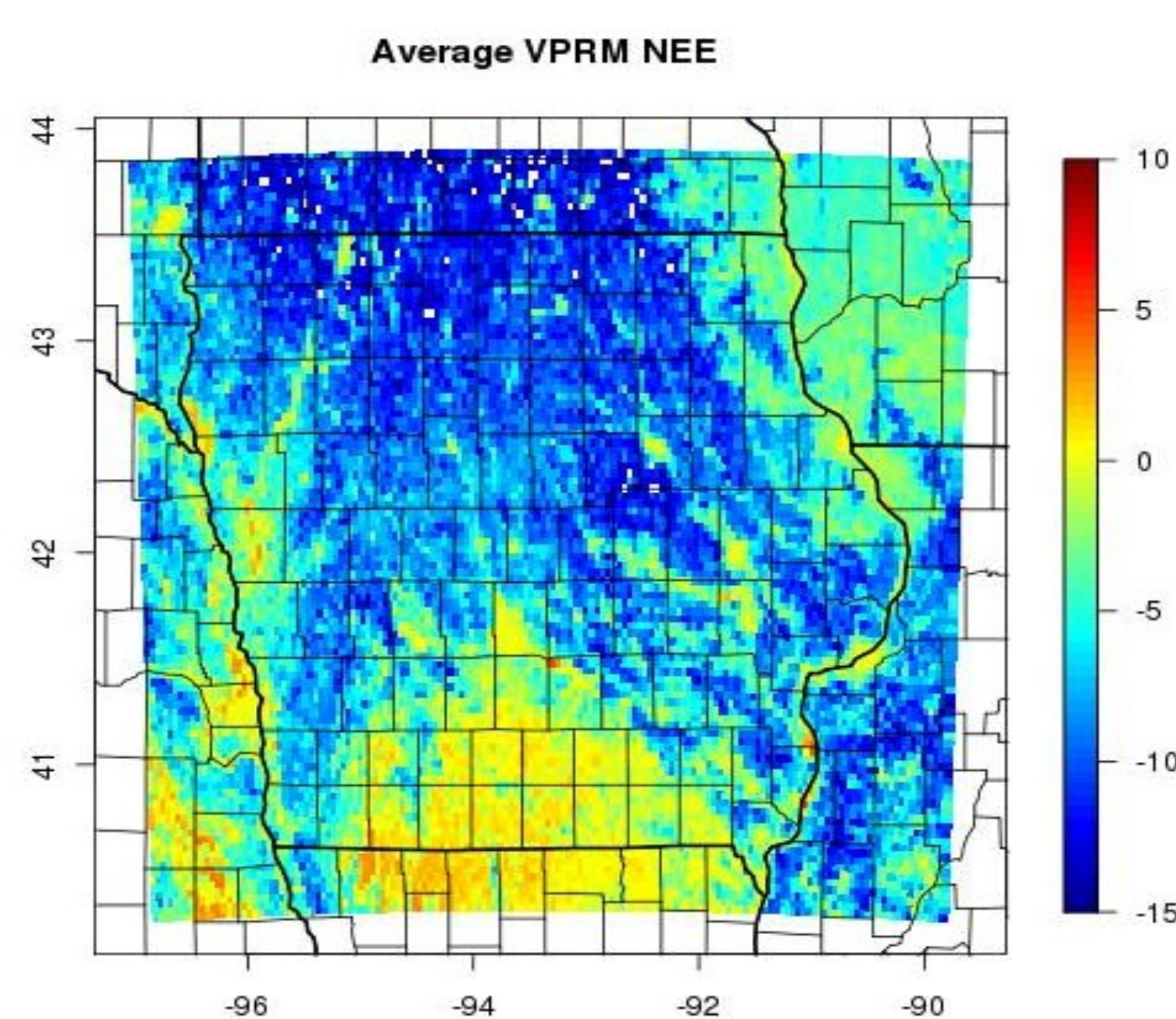
- Benjamin Abban
- Robert Bullard
- Dimitrios Dermisis
- Aditsuda Jamroensan
- Kenneth Wacha
- Morgan Yarker

#### Undergraduate (6):

- Ben Behrendt
- Jessica Carlson
- Kelsey Coulter
- Megan Osayande
- Nicholas Petrich
- Brad Reuter

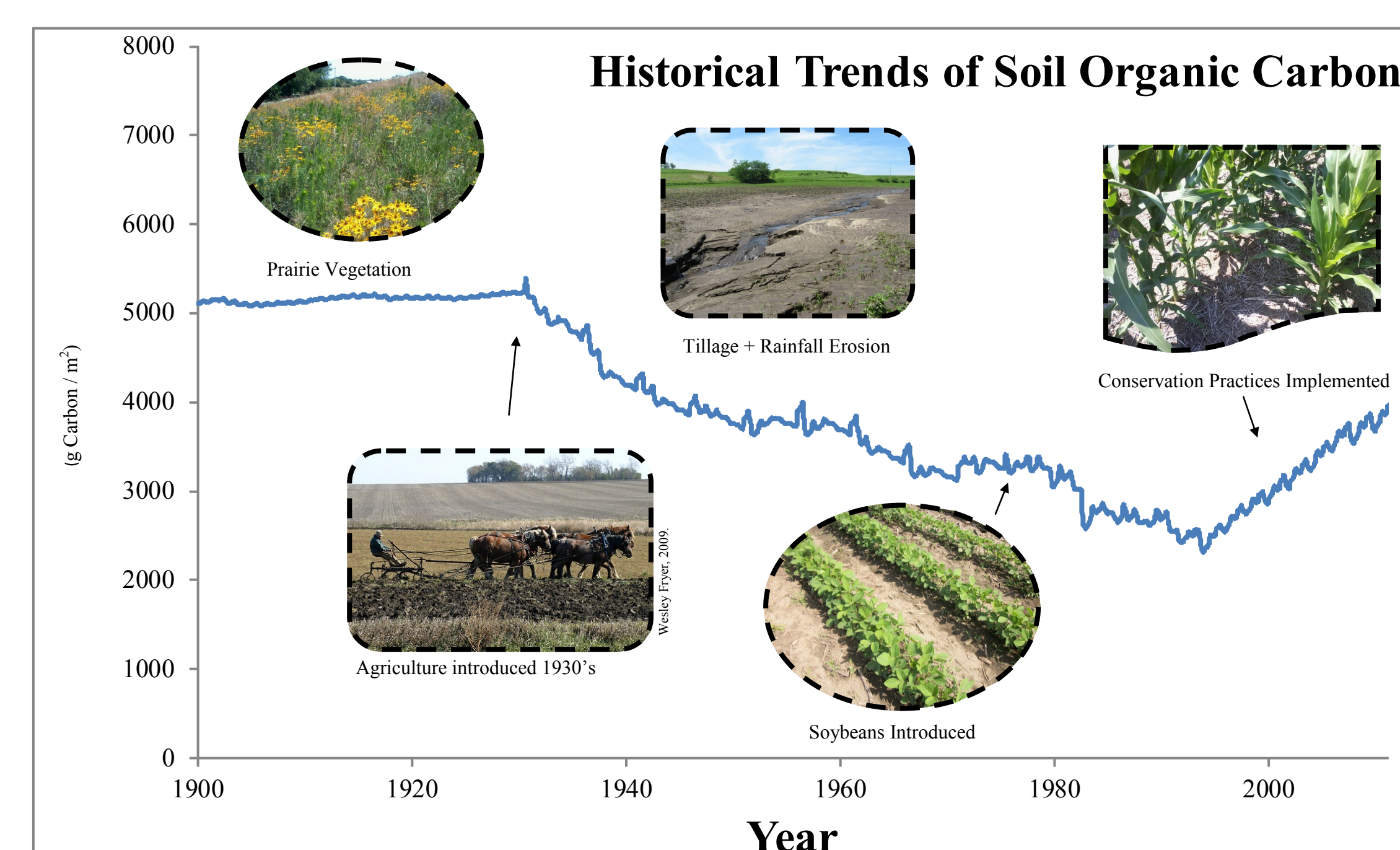
## Findings

### 1) Vegetation Photosynthesis and Respiration Model



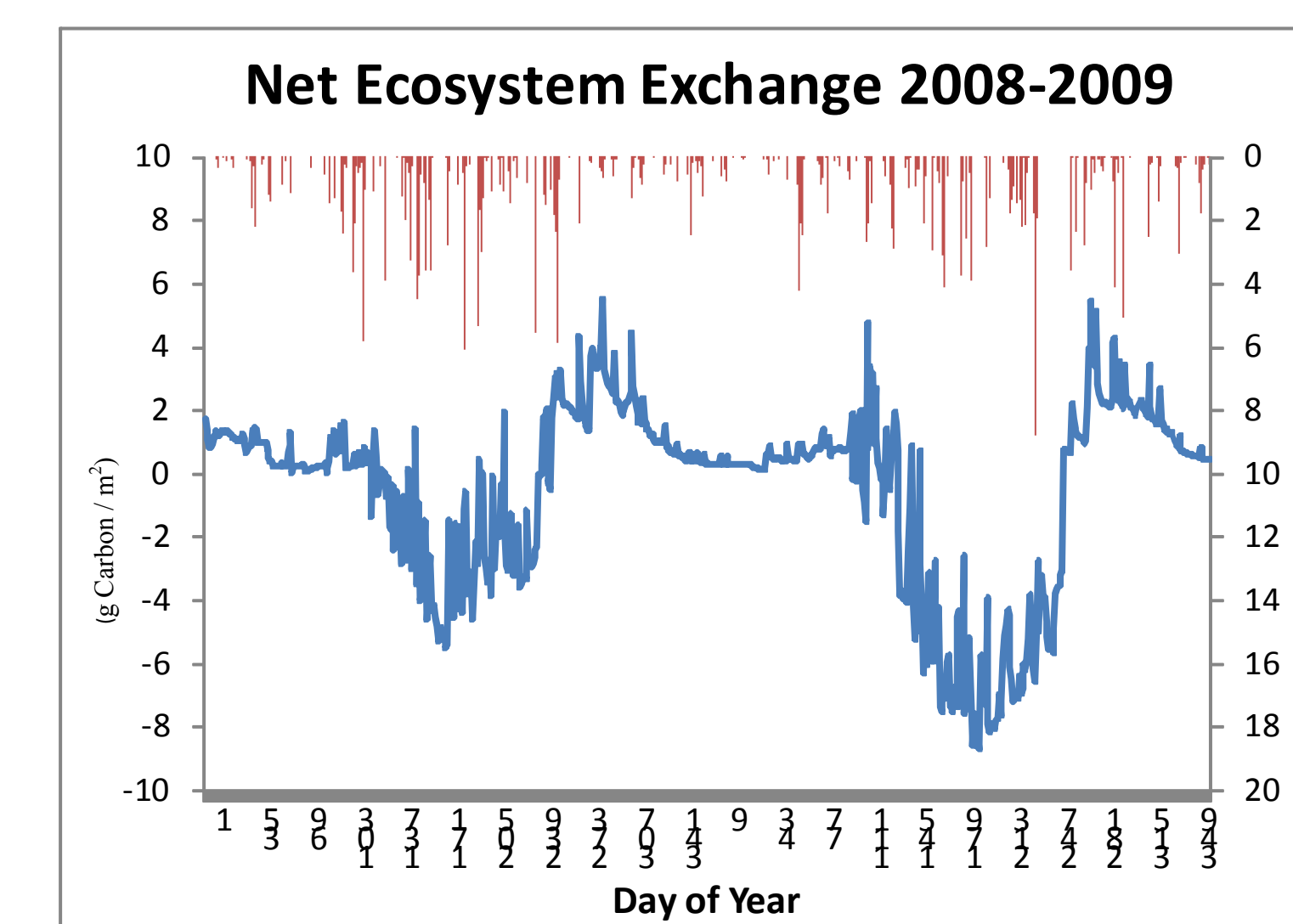
- To run the **Vegetation Photosynthesis and Respiration Model (VPRM)**, we used a 13-class, land cover model with 1-km resolution with data from the National Agricultural Statistics Service and MODIS-derived plant growth parameterization to provide realistic timing of photosynthesis relative to year-to-year variations in climate and land management.
- The VPRM simulations provide to us the Net Ecosystem Exchange (NEE) of C to develop carbon budgets and quantify SOC sequestration potential.

### 2) Effects of Agricultural Land Management Practices on SOC

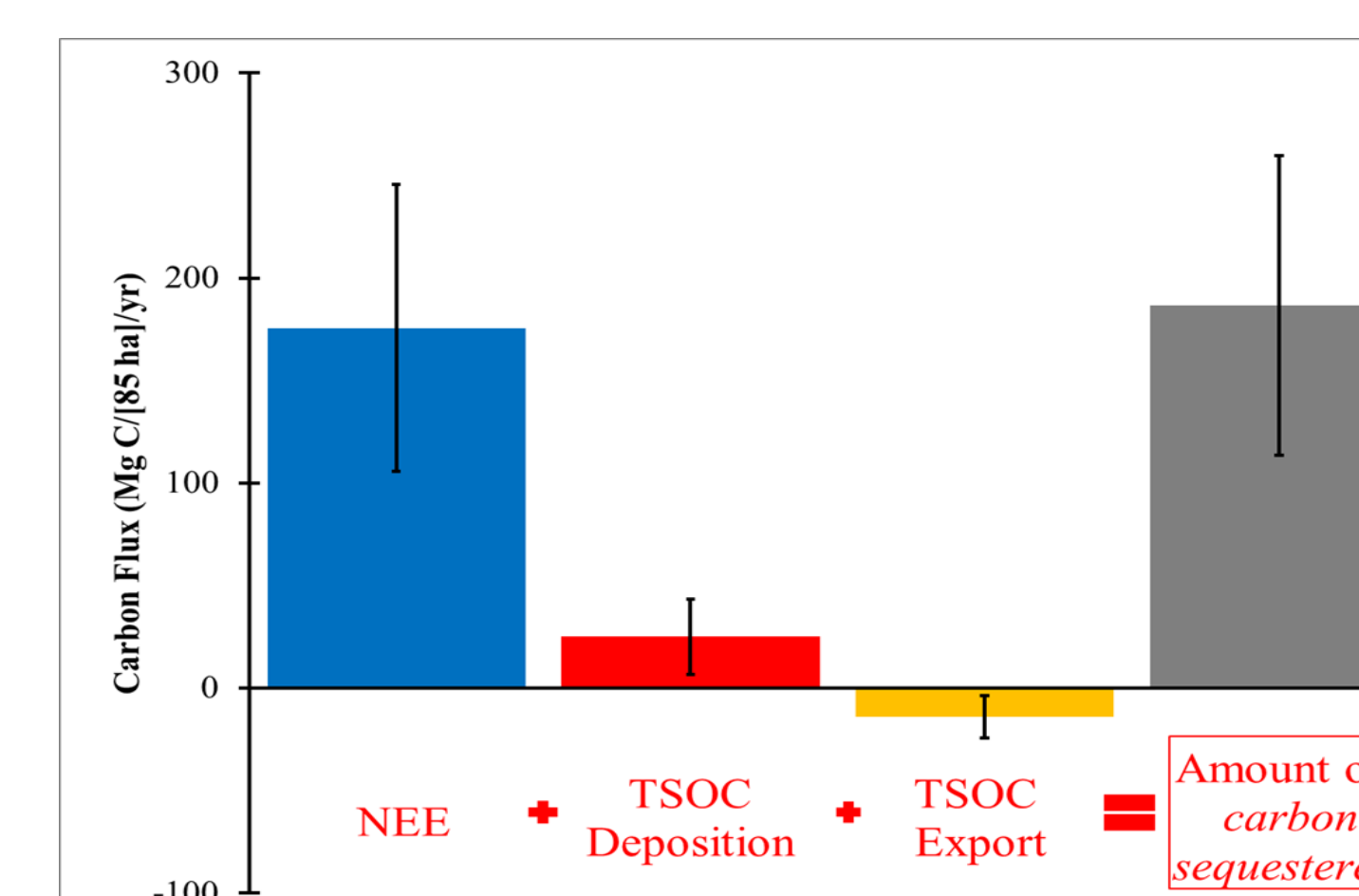


- In agricultural systems, like those that we have here in the Midwest, fluxes of carbon (namely erosion and deposition) move considerable amounts carbon ultimately affecting our C-budgets.
- The **coupled WEPP and CENTURY models** can simulate a wide range of land management practices and provide a physically based quantification of carbon fluxes at the watershed scale.
- These values can be re-introduced into VPRM to scale up our results to state and the Midwest.

### 3) Incorporating Erosion and Soil Respiration



Using our different models, we can develop more detailed budgets of NEE and SOC Sequestration for Iowa.



Current conservation land use practices in Iowa are sequestering carbon in our soils, which increases soil quality and limits CO<sub>2</sub> increases.

## Presentations & Publications

- Anderson, C., Myers, A., Yarker, M., Carlson, J., Stanier, C. "Development and Testing of Hands-on Experiments for Middle School Teachers Regarding Energy Transfer and Climate," poster at Annual Meeting of the American Institute of Chemical Engineers, Minneapolis, MN, 2011.
- Behrendt, B., Bullard, R., Stanier, C. "Height Resolved SO<sub>2</sub> Monitor," Environmental Division student poster session of the Annual Meeting of the American Institute of Chemical Engineers, Minneapolis, MN, 2011.
- Behrendt, B., Bullard, R., and Stanier, C. "Height Resolved SO<sub>2</sub> Monitoring," poster at 2011 University of Iowa College of Engineering Research Open House.
- Coulter, K., Petrich, N., Jamroensan, A., Papanicolaou, T., Carmichael, G., and Stanier, C. "Monitoring and Measuring Iowa's Carbon Balance," poster at 2011 University of Iowa College of Engineering Research Open House.
- Coulter, K., Jamroensan, A., Wilson, C., Petrich, N., Wacha, K., Papanicolaou, T., Carmichael, G., and Stanier, C. "Modeling and Measuring CO<sub>2</sub> in Iowa," poster at the Iowa Space Grant Consortium Executive Committee and Affiliates Meeting, Marshalltown IA, 2011.
- Jamroensan, A., Ahmadov, R., Pétron, G., Carmichael, G., Andrews, A., Sweeney, C., Kretschmer, R., Gerbig, C., Olsen, L., Stanier, C. "Improving Estimates of CO<sub>2</sub> using the WRF-VPRM Biosphere and Transport Model over the Midwest USA," 2011 AGU Fall Meeting, San Francisco, CA, 2011.
- Jamroensan, A., Ahmadov, R., Pétron, G., Carmichael, G., Andrews, A., Kretschmer, R., Gerbig, C., Olsen, L., Stanier, C., Gerbig, C., and Olsen, L. "WRF-VPRM Mesoscale Transport and Biosphere Model Performance using Optimized VPRM Parameters for Midwest USA", presentation at the North American Carbon Program Meeting, New Orleans, LA, 2011.
- Jamroensan, A., Carmichael, G., and Stanier, C. "Effect of Land Cover and Meteorological Boundary Conditions on CO<sub>2</sub> Simulation using WRFVPRM," poster at 2011 University of Iowa College of Engineering Research Open House.
- Malott, T., Stanier, C. "Carbonyl Sulfide In the Earth's Atmosphere: Relevant Reactions and Their Use to Interpret Atmospheric Data," Environmental Division student poster session of the Annual Meeting of the American Institute of Chemical Engineers, Minneapolis, MN, 2011.
- Papanicolaou, A.N., C.G. Wilson, K. Wacha, and T. Moorman. 2011. Watershed scale carbon cycle dynamics in intensively managed landscapes: bridging the knowledge gap to support climate mitigation policies. 34th International Association of Hydraulic Engineering & Research (IAHR) Biennial Congress, Brisbane, Australia.
- Papanicolaou, A.N., D. Dermisis, K. Wacha, B. Abban, and C.G. Wilson. 2011. Agricultural soil erosion and soil organic carbon (SOC) dynamics in the U.S. Midwest: Bridging the knowledge gap across scales. GSA Annual Meeting, Minneapolis, USA.
- Wacha, K.M., A.N. Papanicolaou, and C.G. Wilson. 2011. Total Below-ground Carbon Allocation (TBCA) estimation in an intensively managed agricultural watershed. James F. Jakobsen Graduate Conference, University of Iowa, Iowa City, IA.
- Wacha, K.M., A.N. Papanicolaou, and C.G. Wilson. 2011. Variation of Total Below-ground Carbon Allocation (TBCA) between land management practices. College of Engineering Research Open House, University of Iowa, Iowa City, IA.
- Wacha, K.M., C.G. Wilson, A.N. Papanicolaou, C. Stanier, G. Carmichael, and T.B. Moorman. 2011. Soil carbon sinks and sources in intensively managed agricultural landscapes. 2011 Great Midwestern Space Grant Regional Meeting, Urbana-Champaign, IL.

## Conclusions

- Soil organic carbon (SOC) sequestration potential is directly impacted by agricultural land management practices.
- To provide a highly accurate carbon budget for agricultural systems of the Midwest, there is need to account for carbon redistribution through the processes of erosion and deposition.
- The combination of conservation practices and increased crop yields are collectively building up SOC in agricultural soils.

## Acknowledgements

- This material is based upon work supported by NASA and the Iowa Space Grant Consortium under Grant No. NNX10AK63H.
- We would like to thank our collaborators from NASA, USDA, Iowa State University, and the Leopold Center for their help thus far.



