Understanding and predicting winter soil dynamics and the subsequent effects on spring nitrous oxide emissions.

The time between harvest and planting constitutes over half of the year in temperate regions, but receives less research relative to the growing season. However, biogeochemical processes occur during the entire winter and are especially sensitive to climatic variability in the absence of the buffering capacity usually provided by plants. Many of these processes, such as nutrient leaching and runoff, soil erosion, and greenhouse gas emissions, result in large and negative consequences on environmental quality. A better understanding of soil dynamics outside of the growing season is needed to make predictions and inform decisions. It is the goal of this proposal to increase our understanding of winter biogeochemical processes in agricultural systems through incorporating current knowledge into a modeling platform, expanding our knowledge of one particularly relevant process, and testing the combination of the two through data collection. We will achieve this goal through the following objectives:

Objective 1) Improve a cropping systems model to better predict winter and early spring soil dynamics.
Modeling the agricultural systems we work with is one of the best ways to understand how numerous complex processes interact to produce agronomic and environmental outcomes. Agricultural Production Systems sIMulator (APSIM) is a field-scale, process-based modeling platform that can run on a daily timestep. APSIM was initially developed in Australia and its use in temperate climates has required ad-hoc changes implemented by various research groups. Many cropping systems models simply suspend simulation during winter, while a few have made modifications to account for cold conditions. We propose to collect and evaluate approaches used for modeling winter soil dynamics and formally incorporate them into APSIM.

Objective 2) Determine a relationship between spring nitrous oxide emissions and the climate conditions leading up to spring emissions.
Nitrous oxide (N_2O) emissions in the spring can constitute half of annual emissions and are sensitive to soil moisture, temperature, pH, and carbon and nitrogen concentrations. Focusing on spring N_2O emissions will be a good test of new winter component incorporations in the model. However, there is evidence that in addition to soil dynamics, N_2O fluxes after a thaw are a function of conditions of the preceding freeze such as freeze duration and the lowest minimum temperature reached. We propose using previously collected data from the northern U.S. and Canada (~40 combined years, multiple sites and treatments) to investigate this relationship and improve our ability to model spring N_2O fluxes.

Objective 3) Test model improvements against spring N_2O measurements at an experimental site which has already been used for extensive calibration.
APSIM was recently calibrated for a corn, soybean, and prairie experimental site at Iowa State University using six years of data including daily soil moisture, soil temperature, and tile drainage, as well as less frequently measured biomass, plant C and N concentrations, soil C and N concentrations, and CO_2 efflux. Simulations of processes at this site during the growing season are currently very good. Model improvements for the winter will be tested at this site against all of the aforementioned variables as well as N_2O emissions that will be measured beginning in fall of 2015.