Title: Unifying Physics and Biology to Simulate Microbial Denitrification and Nitrous Oxide Flux with the EPIC Model

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Project Goals: The goal of the DOE Great Lakes Bioenergy Research Center is to perform the basic research that generates technology to produce, sustainably, cellulosic biomass and to convert it to ethanol and other advanced biofuels.

Abstract: Microbial denitrification occurs when nitrate in anaerobic soils and aquatic environments is reduced to form nitrous oxide (N_2O) and dinitrogen gases, which eventually escape to the atmosphere. Nitrous oxide is a potent greenhouse gas and also contributes to reduce the protective layer of ozone in the stratosphere. Atmospheric concentrations of N_2O have been on the rise since the beginning of the industrial revolution due to large-scale manipulations of the N cycle in managed ecosystems; especially through the use of synthetic nitrogenous fertilizer. Process-based simulation models—together with observations—can help design solutions to reduce N_2O emissions from managed ecosystems; especially under a large-scale deployment of biofuel crops and land-use change.[1] Here we describe a process-based submodel of microbial denitrification incorporated in the terrestrial ecosystem model EPIC (Environmental Policy Integrated Climate) and linked to a coupled carbon-nitrogen submodel. Each day during a simulation, EPIC calculates heterotrophic respiration based on carbon-nitrogen pool transformations and adjusted by environmental controls (e.g., temperature, water, mineral nitrogen). EPIC then calculates whether there is enough oxygen to accept the electrons generated by both microbial and root respiration. If oxygen is insufficient, then other nitrogen species (nitrate, nitrite, and nitrous oxide) act as electron acceptors following a competitive inhibition scheme. A ratio of electron accepted / electrons generated is used to correct microbial respiration. An hourly implementation of the gas transport equation is used to move oxygen, carbon dioxide, and nitrous oxide across the gaseous phase of the soil layers and across the soil-atmosphere interface. Examples of model performance will be presented and discussed.

References

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