Nitrification-Derived Nitrous Oxide (N_2O) Emissions from Annual and Perennial Cropping Systems in Southwest Michigan

Di Liang [1,2,3] (liangdi@msu.edu) and G. Philip Robertson [1,2,3]

[1]Great Lakes Bioenergy Research Center (GLBRC); [2]Department of Plant, Soil and Microbial Sciences; and [3]WK. Kellogg Biological Station (KBS); Michigan State University, Hickory Corners, MI

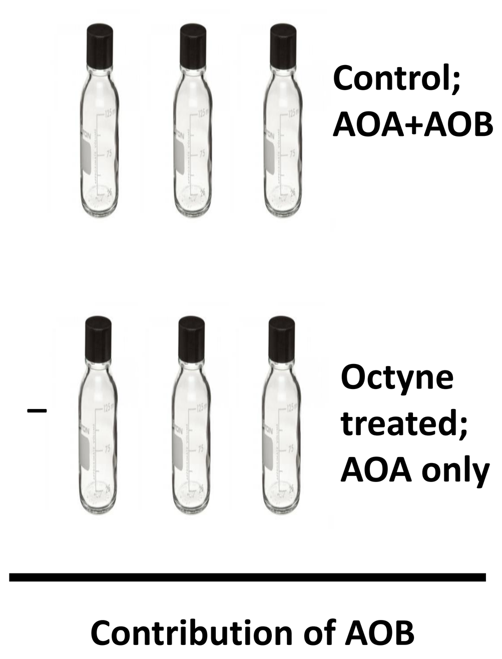
Introduction

Nitrous oxide (N_2O) is a potent greenhouse gas with a global warming potential 300 times higher than CO_2. Soil nitrification, performed mainly by ammonia oxidizing bacteria (AOB) and archaea (AOA), converts ammonia (NH_3) to nitrite (NO_2^-) and nitrate (NO_3^-), and soil denitrification reduces NO_3^- to N_2O and dinitrogen (N_2), are considered the two major pathways leading to N_2O emissions. The relative contribution of each in most soils is still unclear.

In this study, we investigated nitrification derived N_2O kinetics from two annual cropping and one perennial poplar system. We also used Bayesian statistical inference to estimate the contribution of nitrification to field N_2O emissions using 25 years of field N_2O and soil NH_4^+ data.

Experimental Design

Soil samples were taken in summer and winter 2016 and spring 2017 from the Main Cropping System Experiment (MCSE) at the Kellogg Biological Station (KBS) LTER site.



- 1-octyne, a selective inhibitor of AOB, was used to separate nitrification sources.
- N_2O from a control treatment (without inhibitor) minus AOA's contribution were attributed to AOB.

Statistical Analysis

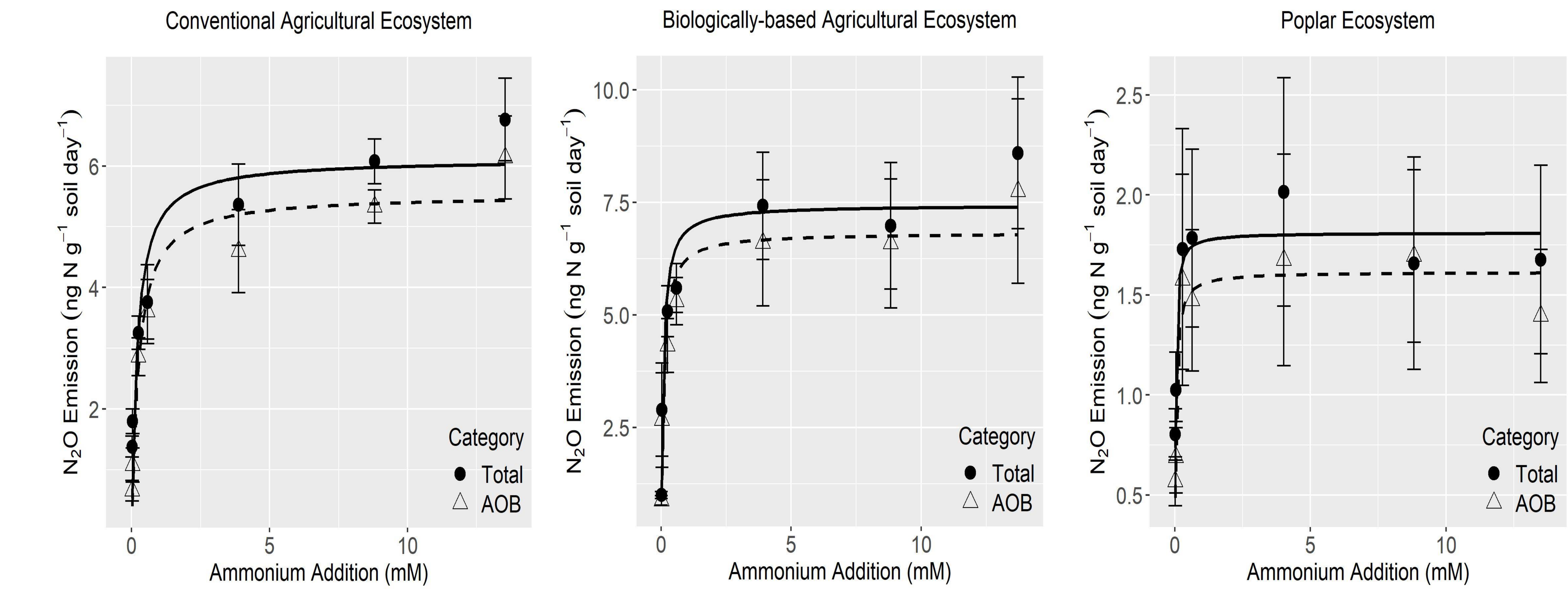
- A Michaelis–Menten kinetics model was used to describe the N_2O-NH_3 relationship:

$$V = \frac{V_{max}S}{K_m + S}$$

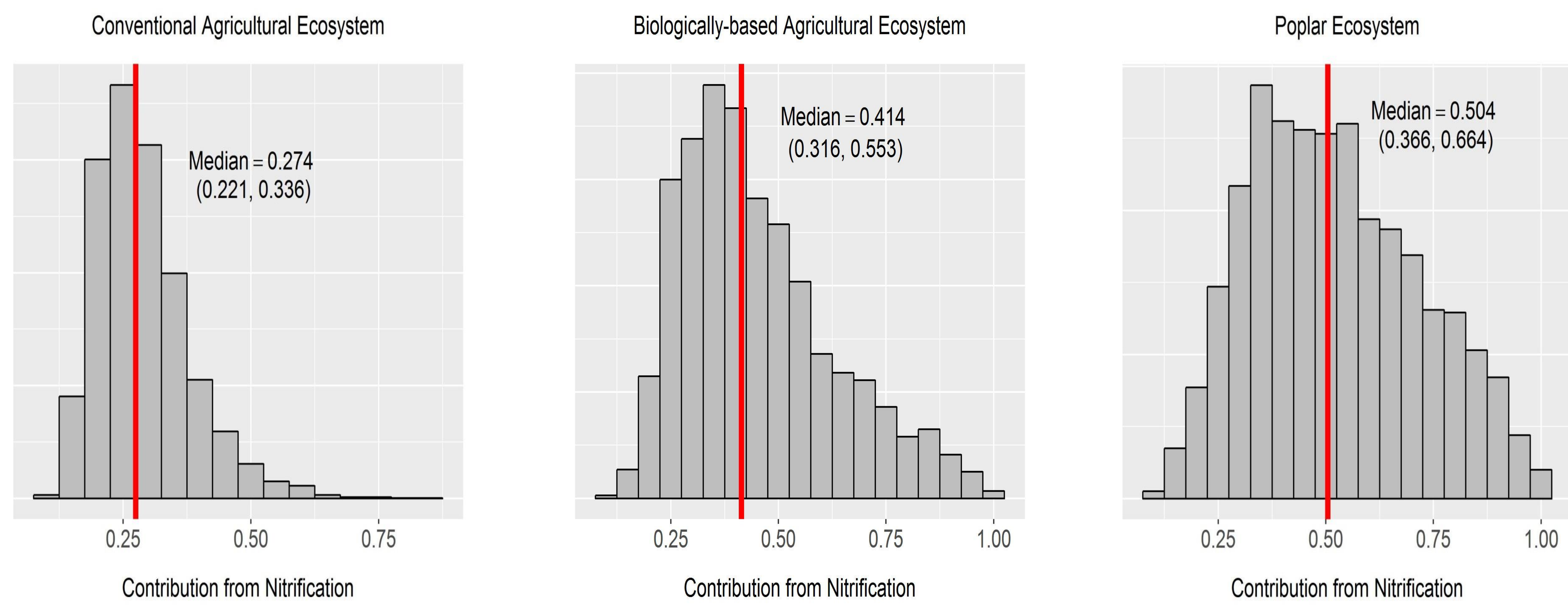
- Posterior distributions of V_{max} and K_m were acquired from Bayesian inference.
- We estimate the contribution of nitrification to field N_2O emissions using 25 years of field N_2O and soil NH_4^+ data.

Results

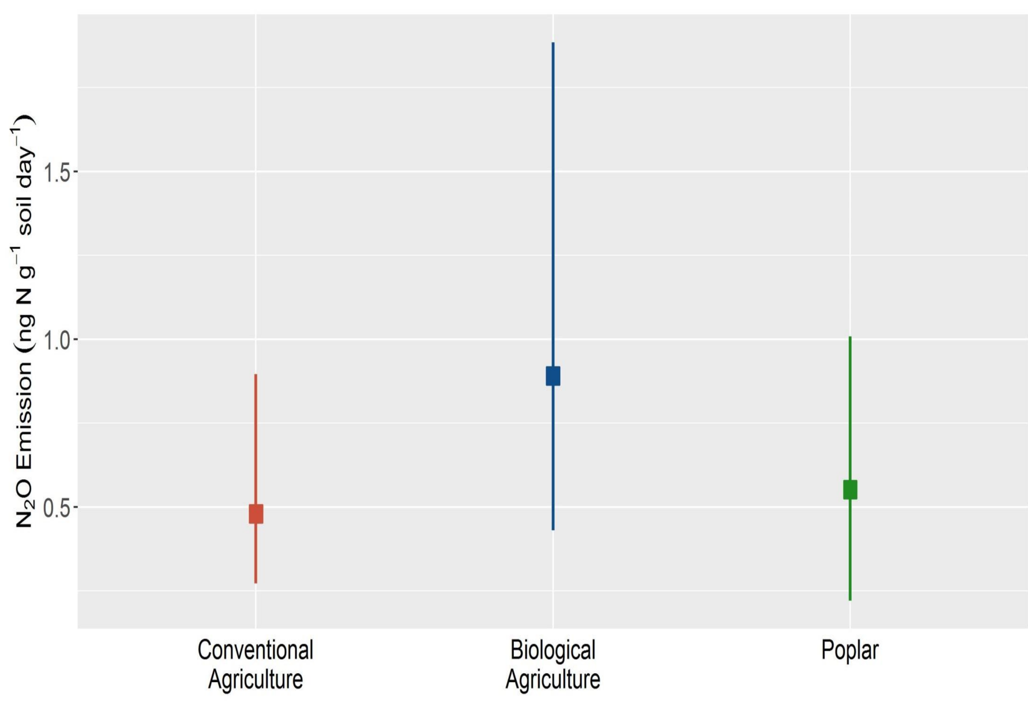
1) N_2O- NH_4^+ relationships modeled by Michaelis-Menten kinetics



2) 25th-75th posterior intervals of contributions from nitrification to total N_2O



3) Nitrification derived N_2O emissions based on the 95% credible interval



Conclusions

- Nitrification derived N_2O emissions exhibit Michaelis-Menten kinetics and AOB dominated nitrifier N_2O emissions in all these ecosystems .
- Nitrification can be a significant but not dominant source of N_2O in these agricultural systems, especially for conventional agricultural ecosystems.

Acknowledgement: Support for this research was provided by the United States Department of Energy (DOE) Office of Science (DE-FCO2-07ER64494) and Office of Energy Efficiency and Renewable Energy (DE-ACO5-76RL01830) to the DOE Great Lakes Bioenergy Research Center, by the National Science Foundation Long-Term Ecological Research Program (DEB 1027253), and by ESPP Urban Environment Summer Research Fellowship and Michigan State University AgBioResearch.