A Rhizosphere-Scale Investigation of the Relationship between Plant Productivity and Methane Emissions from Wetlands

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Abstract: The proposed project will advance understanding of the response of methane production and methane oxidation to changes in plant productivity so that modeled representations of these processes and interactions can improve. Wetland plants both enhance and diminish methane emissions. Carbon exuded by roots into the rhizosphere can fuel methane production, and hollow aerenchyma tissues inside plants can transport methane from soil directly to the atmosphere. However, aerenchyma tissues also mediate diffusion of oxygen down to roots where oxygen leaks into the rhizosphere and can oxidize methane or suppress methanogenesis. Not surprisingly, empirical studies have detected both increases and decreases in methane emissions as plant productivity increases. However, large-scale methane models currently only capture the positive relationship between methane emission and plant productivity, and do not consider the potential negative relationship. Our ability to predict how methane emissions may shift in the future is limited without a full grasp of the factors that favor plant-mediated production of methane versus oxidation/inhibition.

Preliminary results from a 1-D radial rhizosphere-scale model developed by Dr. Neumann's research group indicates that the responses of methane production, methane oxidation and plant-mediated methane emission to increases in plant productivity depend not only on how root inputs of carbon and oxygen change with plant productivity, but also on competitive interactions of microbial communities within the rhizosphere. Guided by these modeling results, we will harness resources available at University of Washington, EMSL and JGI to investigate of the response of methane-relevant microbial reactions to plant inputs of carbon and oxygen. We will grow plants in ambient and elevated CO2 to stimulate different levels of net primary production (NPP). On plants with different levels of NPP we will: (1) track and characterize rhizosphere inputs of carbon and oxygen using planar optical oxygen sensors (UW) and organic carbon extraction followed by FT-ICR-MS (EMSL); (2) identify the spatial arrangement of microbial communities (relative to each other and to the root) and clarify which communities are using root exudates using isotope probing methods (UW & JGI) and ribosomal RNA-targeted fluorescence in situ hybridization with nanoscale secondary ion mass spectrometry (EMSL); and (3) determine microbial activity using flux and porewater measurements (UW) along with transcriptomics (JGI).

Project results will advance understanding of the complex plant and microbial interactions that control methane production and methane oxidation within the rhizosphere of wetland plants, which is of use to both empiricists and modelers focused on understanding and predicting methane emissions from wetlands. Ultimately, the effort can improve modeled representations of the relationship between plant productivity and methane emissions, which will lead to more robust predictions of future methane emissions and climate-methane feedbacks.