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Nitrogen fate during agricultural managed aquifer recharge (Ag-MAR): modeling hydrologic and geochemical processes in a physically and chemically heterogeneous system

CATHY YINGCAN WANG AND REED MAXWELL

Princeton University

Presenting Author: yw3790@princeton.edu

Agricultural managed aquifer recharge (Ag-MAR) is the practice of purposefully flooding farmland with excess surface water to recharge an aquifer under controlled conditions in order to store the water for later extraction, or to achieve environmental benefits. Ag-MAR is an emerging method for sustainable water management and has been practiced in some states such as California in recent years. However, there are concerns about impact on crop yield, as well as potential risks of greenhouse gas emission and groundwater contamination. Understanding and realistically representing the hydrological and biogeochemical processes as well as their interactions in the subsurface is important to quantify the impact of Ag-MAR on N-dynamics. This study focuses on addressing some key inquiries about agricultural managed aquifer recharge (Ag-MAR), such as identifying the dominant processes governing N-dynamics during Ag-MAR, assessing the potential risks of Ag-MAR, and determining the influence of interactions between biogeochemical systems and complex subsurface flow fields on the selection of recharge site locations. To tackle these questions, we developed a loosely coupled hydrogeochemical model based on existing hydrologic and reactive transport models. For hydrologic modeling, we use ParFlow-CLM, a parallel, integrated hydrology model coupled to a land surface model, running over idealized homogeneous domains driven by hourly forcing data from more than 10 selected basin spanning different regional climates across the United States. In this loosely coupled initial approach, resulting P-ET values from ParFlow-CLM are then used as infiltration rates in CrunchFlow for reactive transport modeling. With the coupled hydrogeochemical model, we are able to study nitrogen fate during Ag-MAR at locations with different hydrogeologic conditions, as well as potential impacts of climate change. Work to improve coupling of the models and to extend the coupled model to include more complicated climate change scenarios and geochemical systems is underway.