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Reduced order models to project future trajectories of bioenergy crop yields and soil carbon changes

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Agroecosystem models are widely used to predict the impacts of management and environmental changes on biomass yields and greenhouse gas (GHG) emissions of bioenergy crops. Machine learning (ML) models are emerging as a popular tool to benchmark model projections and make predictions more efficient. In this study, we combined ML and agroecosystem model (DayCent) to project the future trajectories of biomass yield and GHG emissions of three bioenergy crops (miscanthus, sorghum, and switchgrass) over agricultural lands of the continental US. The objectives of our study were to: i) build reduced order models to predict the biomass yield and soil organic carbon (SOC) change for three bioenergy crops, and ii) project the future trajectory of biomass yield and GHG emissions using these reduced order models for high emission scenarios of coupled model intercomparison project phase six models. Random forest model was built using the inputs and outputs from DayCent for individual bioenergy crop. DayCent based ML model was able to predict the SOC change with R^2 ranges of 0.93-0.98 and biomass yield with R^2 ranges of 0.96-0.98 for three bioenergy crops. Changes in biomass yield and SOC were controlled by climatic parameters. In term of biomass yield and carbon sequestration potential, miscanthus and sorghum were found least impacted in comparison to switchgrass under high emission future scenarios. Additionally, comparison of the ML based future trajectory and DayCent future runs show similar trends indicating similar prediction accuracy of reduced order models.