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Impacts of future changes in CO_2, climate, land use and management on ecosystems as simulated by a coupled vegetation/land-use model system

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In a future of increasing atmospheric carbon dioxide (CO_2) concentrations, changing climate, increasing human populations, and changing socioeconomic dynamics, the global agricultural system will need to adapt in order to feed the world. Global modeling can help to explore what these adaptations will look like, and their potential impacts on ecosystems.

To investigate such potential adaptations, a model system has been developed that couples a biologically-representative global vegetation model, LPJ-GUESS, with the PLUMv2 land use model. The coupled model allows for better understanding of the cross-scale interactions between the environmental and agriculture within the global land use and food system. LPJ-GUESS first simulates—at 0.5º resolution across the world—the potential yield of various crops and pasture under a range of management intensities for a time step given its atmospheric CO_2 level and climatic forcings. These potential yield simulations are fed into PLUMv2, which uses them in conjunction with endogenous agricultural commodity demand and prices to produce land use and management inputs (fertilizer and irrigation water) at a sub-national level for the next time step. This process is performed through 2100 for a range of future climate and societal scenarios—the Representative Concentration Pathways (RCPs) and the Shared Socioeconomic Pathways (SSPs), respectively—providing an exploration of possible trajectories of land use and land cover change.

The land use projections produced by PLUMv2 are fed back into LPJ-GUESS to simulate the future impacts of management decisions and land use change, along with increasing CO_2 and climate change, on terrestrial ecosystems. This integrated analysis examines the resulting impacts on ecosystems affecting biophysics (albedo); carbon, nitrogen, and water cycling; and the emission of biogenic volatile organic compounds (BVOCs).