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Simulating the effects of crop growth on land-atmosphere interactions using a coupled mesoscale-dynamic vegetation model

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Land and atmospheric dynamics are tightly coupled. Crop growth affects local micrometeorology by influencing the exchanges of heat, moisture and momentum between the land and the atmosphere. In this study, a dynamic crop growth module is incorporated in the Weather Research Forecasting (WRF) model to explore effects of crop growth on land-atmosphere interactions during the growing season. The crop module is derived from the crop model SUCROS that simulates carbon assimilation by photosynthesis and its allocation into the roots, stem, leaves and storage organs of crops. The crop module is first run in a stand-alone mode and calibrated to match observed LAI from soybean fields in Nebraska and Illinois and spring wheat fields in northern India. Next, it is incorporated as a submodule in the Noah-MP land surface module of WRF. In this coupled form, the fluxes from the land surface are simulated by Noah-MP at every model timestep while the LAI and root depth required for flux calculations are updated daily by the dynamic crop submodule. This coupled model provides better simulations of crop phenology than the generic dynamic vegetation module in Noah-MP. Moreover, the coupled model is able to simulate feedbacks on surface air temperature and humidity associated with changing Bowen Ratio due to crop growth in contrast with prescribed-leaf area index (LAI)-driven methods that is typical in mesoscale models. We have introduced crop yield as a model output that potentially expands the capability of this model to provide seasonal-scale weather and crop yield outlooks.