Introducing Agricultural Feedbacks in Noah Land Surface Model for improved weather and regional crop yield simulations

June 8, 2017

11:00 AM LILLY Hall 2-425

Xing Liu

Xing grew up in Guiyang, China where the averaged rainy days per year is 188. She earned her Bachelor degree in Applied Meteorology from China Agricultural University in Beijing where she spent most of her free time photographing. Xing came to Purdue in 2011 for pursuing her master degree in Agronomy with Dr. Dev Niyogi. She started her Ph.D. with ESE in 2014. After graduation, she plans to work on weather and climate risks analysis for agriculture. Outside of her research, Xing likes drinking coffee, eating ramen, reading cheesy poems and writing nonsense. And she is still trying to figure out how to cross State Street.

Xing knows it is a very long abstract and you probably won't read it. So the short version is: there will be cupcakes and coffee.

This study is motivated by the needs posed from two perspectives: 1) to study crop yields' response under the changing climate, there is an increasing demand for large-scale, regional crop growth simulations; and, 2) croplands play an important role in the modification of local and regional weather and climate but this aspect has been under studied. The poor representation of cropland in the current weather forecast models such as the community Weather Research and Forecasting (WRF)/ Noah-MP land-surface modeling system is a example of the current state of the cropland - atmosphere feedback studies. The lack of detailed crops in the weather models not only limits the ability to better understand the role of agricultural feedbacks in the regional weather, but also directly and indirectly affects the numerical weather prediction of high impact events especially over crop dominated landscapes.

In response to these needs and with the objectives to improve weather and regional crop yield simulation, a new crop model (Noah-MP-Crop) has been developed and implemented into a regional land-surface modeling system. The model was initially developed for corn and soybean, and evaluated at field scale with observations from two crop sites (Bondville, IL, and Mead, NE Ameriflux sites) over a six years period (2001-2006). Results shows improved in the ability of simulating regional meteorological parameters such as dew points and surface energy fluxes. Results also highlighted the importance of soil moisture processes and the rooting depth for further enhancements in the model. A dynamic rooting depth module was developed and introduced into the model, which further improved the model performance.

The newly developed modeling system was then used for conducting regional-scale crop simulations (20km grid spacing and hourly time step for the entire continental U.S. domain) for the 2012 through 2014 calendar year in an offline land data assimilation system (LDAS) mode. The implementation of the regional model also required the development of additional modules to integrate: (i) USDA planting dates dataset, (ii) heuristic estimation of cultivar information using regionally representative planting as well as harvesting dates and climatological growing degree estimates, and (iii) detailed crop land cover by merging satellite and regional and global model based estimates of crop cover. Crop (corn) yield simulations were compared with surveyed data for different agricultural statistics district (ASD) from National Agricultural Statistic Services. Results indicate that by implementing the planting dates and cultivar selections, the Noah-MP-Crop model is able to provide a more accurate regional yield simulation.

The regional version of the crop model and associated datasets were then used to couple Noah-MP-Crop with the WRF model for investigating the impact of cropland on mesoscale short-term convective weather events. The coupled system was used to simulate and study a thunderstorm event that was observed over eastern Iowa- western Illinois region corresponding to a field experiment (PECAN: Plains Elevated Convection at Night experiment, Intensive Observation Period 15). The results show that the enhanced crop simulation captured the spatiotemporal heterogeneity of crop leaf area index (LAI). This in turn influenced the surface energy fluxes and the dew point temperatures as well as mesoscale boundaries. These interacted to modify the precipitation forecasts. Results show promising improvements in the WRF models ability to simulate the land – atmosphere interactions and mesoscale convection by better representation of croplands.

The uniqueness of this study is that by bridging the traditional crop model community and land surface and weather model community, it provides us a new tool and approach for regional crop modeling. Noah-MP-Crop is an easier, faster and open-sourced approach with the potential for real-time crop modeling at flexible spatial and temporal resolutions. By enhancing the cropland representation in weather model, improvements in the regional hydroclimatology as well as weather simulation are now possible. This research is a result of collaborations with researchers from National Center for Atmospheric Science (NCAR), and National Centers for Environmental Prediction (NCEP) and utilizes multiple publily available datasets and model frameworks.

The coupled WRF/Noah-MP-Crop model has been released as a public version (WRF v3.9) in April 2017.