Seasonal Dynamical Downscaling for Crop Yield Estimation

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This study describes the significant role of the CLM2 (Bonan et al. 2002) in the seasonal dynamical downscaling of surface fields (maximum and minimum temperatures, precipitation, and solar radiation) through the FSU regional climate model and explores the suitability of these surface fields for crop yield estimations using the CSM CROPGRO-peanut model (Jones et al. 2003). Seasonal simulations for peanut growing season with the atmospheric regional model coupled to the CLM2 (FSUCLM; Shin et al. 2005) are compared to those with the control (FSUc, i.e., the original FSU model). Two convective schemes (SAS and RAS) are also employed in this comparison.

The importance of the land model was clearly shown in seasonally downscaled surface climate simulations (Figs. 1 and 2). Three fields (maximum and minimum temperatures and solar radiation), among four input fields for use in a crop model, were simulated close to the observed seasonal climate in the new land model setup. However, precipitation was not since the amount of rainfall is mostly determined by the convective scheme. Nevertheless, the new land model modulated latent heat fluxes (or evaporation) better and provided a slightly better seasonal rainfall amount with the SAS scheme. In spite of noticeable gaps between the observed and the model seasonal climates, the regional climate model with the CLM2 provided more accurate site- and year-specific seasonal surface climates suitable for the crop model use (Fig. 3), resulting in improved estimation of peanut development and yield (Fig. 4). The FSUCLM with the SAS scheme exhibited its potential for simulating the interannual variability of crop yields. However, a conclusive statement cannot be made at this stage of the study. More work needs to be done to evaluate the skill of the model and to determine if the model has similar skill during other seasons, different locations, or different crop types.

In order to build a firm bridge between the climate model and the crop model, the following must be studied. First, a method should be developed to correct the inaccurate model precipitation by some dynamical and/or statistical methods. Second, ensemble simulations are needed to have a statistically significant result. These will be used to make probabilistic forecasts of the crop yield. Third, a coupled ocean-atmosphere model should be used instead of the prescribed sea surface temperature to provide an actual seasonal forecast to drive the crop model. Finally, a coupled version of atmospheric and crop models should be developed to capture the nonlinear seasonal weather-yield interactions. A comparison study is also needed to measure the current skill levels of dynamical downscaling approach compared to the statistical/empirical methods.

Acknowledgements
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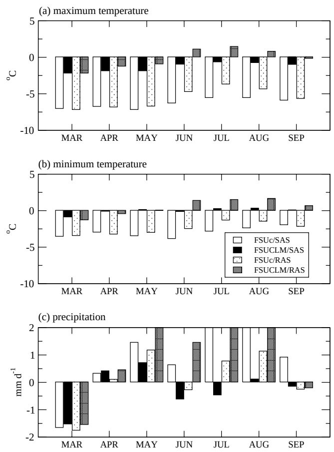

Fig. 1: Climatological (10-yr average) differences between model forecasts and the site-based observations for monthly mean (a) maximum temperature, (b) minimum temperature, and (c) rainfall amount. Values are averaged over the target states (FL, AL, and GA).

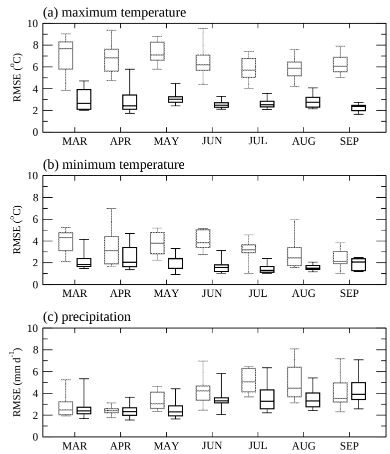

Fig. 2: Box-whisker diagrams of RMSE for monthly mean (a) maximum temperature, (b) minimum temperature, and (c) rainfall amount over the target states (FL, AL, and GA). The box shows the upper and lower quartiles, the line within the box shows the median and the whiskers show the full extent of the data (10 individual years). While gray boxes are for the FSUc/SAS, dark boxes are for the FSUCLM/RAS.

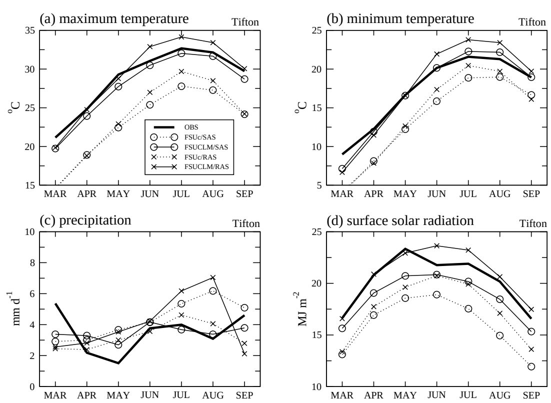

Fig. 3: Monthly mean (a) maximum temperature (^{o}C), (b) minimum temperature (^{o}C), (c) rainfall amount (mm d^{-1}), and (d) solar radiation (MJ m^{-2}) for Tifton, GA from the climatology (10-yr average observation) and four corresponding model simulations.

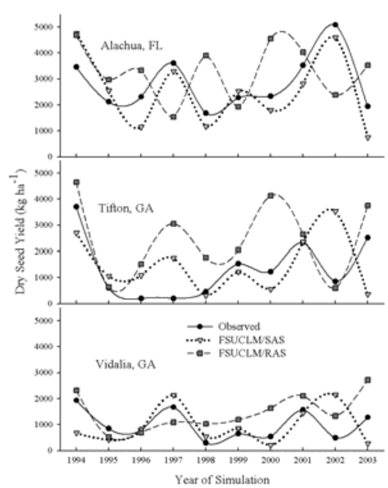

Fig. 4: Peanut (variety Georgia Green) yields from 1994 to 2003 simulated at three locations in the southeast U.S. using observed daily weather (circle) and the model daily values from the FSUCLM/SAS (triangle) and the FSUCLM/RAS (square).

References

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