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Effects of input uncertainty on cross-scale crop modeling

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The quality of data on climate, soils and agricultural management in the tropics is in general low or data is scarce leading to uncertainty in process-based modeling of cropping systems. Process-based crop models are common tools for simulating crop yields and crop production in climate change impact studies, studies on mitigation and adaptation options or food security studies. Crop modelers are concerned about input data accuracy as this, together with an adequate representation of plant physiology processes and choice of model parameters, are the key factors for a reliable simulation. For example, assuming an error in measurements of air temperature, radiation and precipitation of ± 0.2°C, ± 2 % and ± 3 % respectively, Fodor & Kovacs (2005) estimate that this translates into an uncertainty of 5-7 % in yield and biomass simulations.

In our study we seek to answer the following questions: (1) are there important uncertainties in the spatial variability of simulated crop yields on the grid-cell level displayed on maps, (2) are there important uncertainties in the temporal variability of simulated crop yields on the aggregated, national level displayed in time-series, and (3) how does the accuracy of different soil, climate and management information influence the simulated crop yields in two crop models designed for use at different spatial scales? The study will help to determine whether more detailed information improves the simulations and to advise model users on the uncertainty related to input data.

We analyse the performance of the point-scale crop model APSIM (Keating et al., 2003) and the global scale crop model LPJmL (Bondeau et al., 2007) with different climate information (monthly and daily) and soil conditions (global soil map and African soil map) under different agricultural management (uniform and variable sowing dates) for the low-input maize-growing areas in Burkina Faso/West Africa. We test the models′ response to different levels of input data from very little to very detailed information, and compare the models′ abilities to represent the spatial variability and temporal variability in crop yields. We display the uncertainty in crop yield simulations from different input data and crop models in Taylor diagrams which are a graphical summary of the similarity between simulations and observations (Taylor, 2001).

The observed spatial variability can be represented well from both models (R=0.6-0.8) but APSIM predicts higher spatial variability than LPJmL due to its sensitivity to soil parameters. Simulations with the same crop model, climate and sowing dates have similar statistics and therefore similar skill to reproduce the observed spatial variability. Soil data is less important for the skill of a crop model to reproduce the observed spatial variability. However, the uncertainty in simulated spatial variability from the two crop models is larger than from input data settings and APSIM is more sensitive to input data then LPJmL. Even with a detailed, point-scale crop model and detailed input data it is difficult to capture the complexity and diversity in maize cropping systems.