AgMIP Regional Team Crop Modeling Webinar

Ken Boote with Help from Teams
Sep 19 & Oct 7, 2013

Example elements for crop modeling in AgMIP reports
Webinar Goals:

- Review figures and tables that will aid in the interpretation of the crop modeling portion of AgMIP regional integrated assessments.

- Analyze and interpret example figures and tables for:
  - Crop model calibration of genetic coefficients,
  - Inputs and assumptions for farm survey simulations,
  - Cumulative probability distributions of farm survey yields (observed and simulated multi-model), and
  - Simulated response (mean, box-and-whisker) for baseline and climate change simulations.

- Illustrate typical adaptations done by crop modelers.

- Identify areas where interactions with crop modelers are needed, and interpretation of survey simulations & climate scenario effects.
Presentations should include:

1) List of genetic coefficients for cultivars, along with figures and statistics for cultivar calibration with sentinel site experiment data.

2) Text description of farm survey yield data, describing site, weather, soils, cultivars, sowing dates, water-management, and fertilizer applied.

3) Brief description of assumptions of initial conditions for soil water, soil nitrate-ammonium, prior crop residue, start of simulation, fertilization dates, soil fertility (SLPF), fraction inert SOC (or SOM3-DSSAT), rooting pattern, and other missing inputs. Defend assumptions.

4) Figures of cumulative probability of exceedance for simulated (2 models) and observed farm survey yields, for survey years, along with interpretation.

5) Box and whisker plot of yield for 1 representative site under 1) 30-year current climate, 2) 30-year future climate with current management, 3) 30-year future climate with adaptations. Interpret climate effects.

6) Box and whisker plot of yield for 1 representative site, with the 5 GCMs and the 20 GCMs (that climate scientists asked for).
Examples SSA & SA Teams

- Examples from SSA and SA Teams (July-August 2013) for:
  - Genetic coefficient calibration with Sentinel Experiment Data
  - Cumulative Frequency Distributions of Simulated Yields compared with observed Household Yield Data, for survey years only
  - Simulated yield response sensitivity for Current Weather and Future Climate Scenarios
Crop : Maize  **Calibrating Genetics**  Variety : Dekalb 900 M

Model used:  DSSAT- CERES- Maize

Data source : Field experiments conducted at ANGRAU, Hyderabad (2007-2008)

Treatments:  3 dates of sowing

N levels  
0 kg/ha
100 kg/ha
200 kg/ha
300 kg/ha
400 kg/ha

**Genetic Coefficients- Dekalb 900 M**

P1 : 250; P2: 0.8; P5 : 950; G2: 820; G3 : 7.4  PHINT : 50
1:1 graph of observed and simulated yields – Cultivar Calibration
Maize for Sentinel Experiment Site. *List model, cultivar, site, statistics.*
*Show 1:1 graph or table of simulated vs. obs anthesis & maturity.*
Inputs & Assumptions for Yield Survey Simulation

Text summary of site (# farms), weather, soils, cultivar, general sowing dates, typical fertilization, initial condition assumptions on soil water, N, SOC.

1. Lat. & Long of Field
2. Planting Date
3. Plant population
4. Row Spacing, Sowing Depth
5. Harvest Yield (and Total Biomass)
6. N Application: Amounts and Dates
7. Manure Application: Amounts and Dates
8. Soil (by soil layer):
   1. LL, DUL, SAT
   2. Bulk Density, Clay, Silt, Sand, Coarse Fraction
   3. Soil Organic Carbon
   4. SOM3 (or inert SOC)
9. Initial Conditions:
   1. Percent initial soil water
   2. Mineral N: NO3 and NH4 (ppm)
   3. Surface Residue (kg/ha) and N conc.
   4. Prior Crop Root Residue (kg/ha)

Other:
1. Weather (Tmax, Tmin, Solar Radiation, Rainfall)
2. Cultivar (genotypic traits)

Blue = survey
Green = Assumptions for DOME from Agronomists
Document Assumptions – Initial Conditions

**Brief text summary of critical assumptions on how you did the simulations relative to the following conditions:**

- Initial soil water (fraction)?
- Initial soil NO3 (ppm) and NH4 (ppm)?
- Prior crop residue (kg/ha) & prior crop type?
- Did you run CENTURY (yes or no)?
- Did you use DOME function to set fraction stable SOM in topsoil, fraction at depth? Provide soil files with the SOM3 or fraction inert SOC values that were used.
- Starting date of simulation (day)?
- Irrigation assumptions (method)
- Other (SLPF, rooting default, rates & dates of N?)
- CO2 turned on (APSIM)?
- Document weather files and CO2 levels used
Cumulative frequency distribution showing distribution of CERES-maize simulated yields and the observed farm survey yields for the farm survey sites.

Need 2 crop models, list crop, site, year, and brief interpretation.

NOTE: Do not use smoothing. Just connect the points.
Comparison of APSIM and DSSAT simulated wheat yield and observed farm yield in India

Need site, year, and interpretation,
Crop Modeling – W. Africa Team

**Need sites & years**

**Millet**

**Maize**

**Peanut**

- Model simulations: Variability across survey fields (1 year!!).
- Models have difficulty capturing the range of actual yields observed in the survey data year. One reason: peanut is not responsive to soil N variation.
- Millet was the best case except for APSIM (problem with tillering)
Exceeding probability of DSSAT and APSIM with Observed data of 155 Farmers

Need crop, region, year, country, & AgMIP-Pakistan. Graph & stats are good

<table>
<thead>
<tr>
<th></th>
<th>DSSAT</th>
<th>APSIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMSE (kg ha(^{-1}))</td>
<td>425.46</td>
<td>440.48</td>
</tr>
<tr>
<td>D-STAT</td>
<td>0.784</td>
<td>0.786</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.52</td>
<td>0.44</td>
</tr>
</tbody>
</table>
Matched District Scenario – South Africa

Using DAFF’s maize yields derived from a postal survey for the Bloemfontein district (1980-2010)

\[ y = 1.345x \]
\[ R^2 = 0.758 \]

\[ y = 0.9384x \]
\[ R^2 = 0.766 \]

Variation is from years, not farms
Distribution of observed, simulated baseline (current) and climate change maize grain yields of 47 farms in Machokas, Kenya.

**Problem:** Is simulated base for 1 year or 30 years? In prior figures, showed CFD for observed survey & simulated for 1 year. For future climate change, need 30 year current and 30-year future. Need auto sowing rules in Strategy Dome.

Mean-Ob = 1326; SD = 1515
Mean Baseline = 1323; SD = 1130
Mean CC = 1008; SD = 713
Probability of exceedance for yield of N-fertilized maize in long rainy season Katumani, Kenya, simulated with CERES-Maize with base and 3 climate scenarios.

*Shows climate effect. Points are means for each of 47 farms, averaged over 30-years of weather. Variability is from farms & climate, not interannual.*
**Box-and-whisker plot of climate effect for two crop models. Simulations are for a single district (i.e., 1 farm or site). Variability is from interannual only.**

**South Africa**

Appropriate to show climate effect on mean yield and interannual variance of yield for 5 GCMs or 20 GCMs. This will NOT go to economists.
Comparison of APSIM and DSSAT results of 155 farmers data with five GCMs

Incomplete: Need crop, year, region, & AgMIP-Pakistan.
Is variation from interannual variation or farms?
Comparison of APSIM and DSSAT simulated rice yield for 155 farmers in ??? Region in Pakistan, using climate from five GCMs. AgMIP-Pakistan
Intercomparison between DSSAT and APSIM using five GCMs with Baseline

Need crop and region. Busy. What is x-axis? Farm variation? Base repeats?
Comparison of simulated wheat yield during baseline (1980-2010) and future period (2040-2069)

Caution: Future time trend is meaningless, as “delta” method is superimposed on historical baseline weather.

What site? Irrigated?

Mean 4035 kg/ha

Percent decrease 26.5

Mean 2965 kg/ha
Indo-Gangetic Basin (Site- Modipuram, India and Crop – Wheat)

Progress so far - Wheat simulation completed for survey data (76 farms), Baseline and future (5 GCMs) using DSSAT and APSIM models.

Variability in observed and simulated (DSSAT & APSIM) wheat grain yields
Comparison of baseline and future simulation yields

Comparison of baseline simulation between DSSAT and APSIM and its mean

*Need crop, region, year, country? Source of variation? Interannual?*

Comparison of simulations using DSSAT and APSIM using 5 GCMs future climate change scenarios
• Variation comes from multiple farms and multiple years.
• The survey data has multiple farms but one year (so variability in CDF is from farm to farm variation, not really weather?).
• Variability in current and future climate scenarios comes from multiple weather years (mean=climate, variation=interannual).
• Teams are simulating all survey fields (50 or so), each with 30 year weather (current, and then future).
• In all cases, pass all data to the economists. They will compute climate change ratio for each farm (future / current) based on the average yield over 30 years (current & future weather). Economists do not use interannual variation yet.
• When to use a box-and-whisker plot? Only when simulating a single site (sentinel site if same region, or a single farm field-mid-way in the yield range). Shows mean yield & interannual distribution caused by weather years.
Examples of Adaptations – Crop Model

• Document Cultivar improvement traits
  – Life Cycle (increase GDD to anthesis & maturity)
  – Drought tolerance (deeper rooting, lower LL-soil)
  – Hybrid Rice (available technology) – increase RUE, grain number, etc.

• Document Management changes
  – Increase N rate
  – Vary sowing date (take advantage of monsoon)

• Document other management depending on economists
The Way Forward

- We want to see your figures and tables.

- We need to know how you calibrated cultivars, the data used, the cultivar coefficients, and evidence of good calibration (Figures & Tables).

- We need to know your assumptions for all those required model inputs missing from the farm survey information, such as initial conditions for soil water, SOC, inorganic N, prior crop residue, etc.

- We can help you with interpreting model and input causes for yield distributions if you provide the figures and above input assumptions.

- We can help interpret reasons for different crop model output if obtaining delta temperature and rainfall for scenarios from climate scientists.

Please contact us if we can help in any way
SAAMIIP

Typical expected results from underway crop modelling analysis
September, 2013
This are examples-which were discussed in SAAMIIP’s
in house meeting 2-3 September, 2013
Calibration of cultivar co-efficients
La Mercy, South Africa (2040-2070)

Yield (t/ha)

Climate scenario

Baseline DSSAT
Baseline APSIM
GCM1 DSSAT
GCM1 APSIM
GCM2 DSSAT
GCM2 APSIM
GCM3 DSSAT
GCM3 APSIM
GCM4 DSSAT
GCM4 APSIM
GCM5 DSSAT
GCM5 APSIM
AvgGCMs DSSAT
AvgGCMs APSIM

Min
Median
Max

Identify crop
Probability of exceedance graphs

Complex with so many lines. Not as good for poster.
Sensitivity analysis

Label as adaptations?
Identify crop and site

Relative future yield (future - baseline, t/ha)

-30% fert -10% fert +0% fert +10% fert +30% fert -30% OM -20% OM -10% OM +0% OM +10% OM
Short season Medium season Long season
CLIPs

• We looked at effects of fertility treatments and climate (base climate and 6 GCMs_E, I, K, O, R) on maize grain production in Nkayi district.

• Fertility treatments were N0= No fertilizer, N17 = 50 kg AN/ha, 52N = 150 kg AN/ha and MMR = Maize with mucuna residues applied at varying rates
Effects of fertility treatment and climate on maize production in Nkayi District Zimbabwe