How precisely do maize crop models simulate the impact of climate change variables on yields and water use?

[Durand Jean-Louis et al.]

[AgMIP]

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The Agricultural model intercomparison and improvement project for maize

1. Catches more aspects of real crops
2. Brings together more scientists from a larger area
3. Helps communicating between scientists and improves knowledge
4. More convincing results
5. Easier to share conclusions and questions
Why Maize?

• Widely croped.
• Large interest in improving that crop (genetics and management).
• Model for other C4 species in terms of response to climate change.
• Many models of maize productivity allowing for proper incertitude analysis.
Maize Yield (T/ha) Western Europe, World and Southern Africa
FAO Stat

0.07 T/ha/year. More than 184 M ha in 2013
Specific Objectives

• Intercompare maize models relative to yield and water use across multiple locations with contrasted potentials under well watered conditions.
• Evaluate the response of the ensemble of models to level of knowledge about the site.
• Utilize the models to evaluate projected production under climate change and variability, and especially high T and [CO2].
• Improve models.
AgMIP Maize models sites used to test models

- High input calibration maize simulations vs. climate factors
  - 19 models for temperature
  - 15 models for CO₂
- 4 contrasting field experiments
  - Morogoro, Tanzania (06.50 S; 37.39 E) Tavg. 22.5 C st.dev.1.4
  - Rio Verde, Brazil (17.52 S; 51.43 W) Tavg. 23.3 C st.dev.1.7
  - Ames, Iowa, USA (42.01 N; 93.45 W) Tavg. 20.6 C st.dev.4.5
  - Lusignan, France (46.25 N; 00.07 E) Tavg. 16.8 C st.dev.3.8

Simulation protocols

Each model under the responsibility of one particular team with 3 successive tasks.

1. Simulate observed yields and water use at 4 sites with a minimum of local data: cv phenology, soil, weather, techniques.

2. Adjust parameters with all experimental data on yields, LAI, nitrogen etc...

3. Simulate the ΔCO2 * ΔT responses over 30 years.
High yield variability challenges simulations of best models. Ensemble 23 models simulated yields accurately with a low level of input information (weather, soil and techniques). The minimum number appears linked to the site².

Martre et al. 2015. Multimodel ensembles of wheat growth: many models are better than one. Global Change Biology.
Most models: maize yield declines in response to temperature increase.
Models agree about the response of phenology to temperature increase:

- a) Lusignan, France
- b) Ames, USA
- c) Morogoro, Tanzania
- d) Rio Verde, Brazil

The graphs show the relationship between days after sowing (DAS) and temperature in different locations. The x-axis represents temperature in °C, and the y-axis represents days after sowing.
For most of models, a 6°C temperature increase, will not increase the simulated interannual variability.
Slight positive impact of $[\text{CO}_2]$ but with high variability:

- Reliable?
- How is it related to water use?
Slight negative impact of \([\text{CO}_2]\) but even higher variability:
• Reliable?
• How is it related to conductance or leaf area?
Conclusions

• Agreement between model teams about T impacts.
• Temperature increase tends to reduce maize yields through shortening of the growth cycle.
• Simulated relative interannual variability not sensitive to T increase.
• Water use remains unchanged. But
• Maintaining the yield increase is possible only where enough water is available.
• Very large incertitude about the CO2 impacts.
• Need to test CO2 response of models simulations against real data: currently in construction in AgMIP.
• Too large incertitude in water use by crops: need to check water use routines in models for taking CO2 impacts into account.