The Ag-GRID Global Gridded Crop Model Intercomparison (GGCMI)

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• Hub for a new generation of gridded crop modeling and data activities within AgMIP
• Includes >18 modeling groups so far and >10 data partners
• Helps coordinate global and regional multi-model assessments
• Synthesis platform for AgMIP data, expertise, IT, etc.
• **GGCMI**: flagship project of Ag-GRID
• 3 distinct model types: 1) Gridded process models, 2) Dynamic global vegetation and land-surface models, 3) Empirical/process model hybrids
Global Gridded Crop Model
Results (1)

Updating IPCC AR4

- AR-4 based on synthesis of small number of point-based simulation experiments in uncoordinated locations (orange)

- Update based on evaluating 7 GGCMs, 5 GCMs, and 4 RCPs in top 20 Food-Producing Units in each zone; part of ISI-MIP

- Extends understanding spatially, beyond +5°C, to more crops, with explicit multi-model agreement described

- Results broadly consistent with AR4 (major low-latitude yield declines), with indications of more negative impacts at lower temperature increases

- Major distinction between models that consider explicit nitrogen stress (pDSSAT, EPIC, GEPIC, and PEGASUS) and those that do not (LPJmL, LPJ-GUESS, IMAGE)

Rosenzweig et al., 2013. PNAS (in press)
Lower latitudes are more vulnerable to climate change
Higher-latitude expansion potential but needs further investigation
Models that incorporate realistic nitrogen see significantly less gains from [CO2] effects at present-day fertilizer levels
Climate, Irrigation, and Adaptation

• With [CO₂] effects, direct climate impacts to maize/soy/wheat/rice involve losses of 400-1400 Pcal (8-24% of present) w/o [CO₂] = 1400-2600 Pcal

• Freshwater limits in some irrigated regions imply reversion of 20-60 Mha of cropland to rainfed by 2100, and a further loss of 600-2900 Pcal

• Net globally, surplus water could support a net increase in irrigation to ameliorate 12-57% of the caloric production lost due to the direct effects of climate change.

Elliott et al. (2013). Constraints and potentials of future irrigation water availability on global agricultural production under climate change. PNAS, in press.
• With CO₂ effects, global CWP increases 5.6 ± 26.6 to 17.3 ± 20.3% by 2080s
• Without CO₂ effects, global CWP decreases by −14.0 ± 16.5 to −28.4 ± 13.9%
• Disparities among GGCMs results double when including CO₂ effects
• Median of GGCMs comparable to FACE data except for rainfed maize

**Source:** Deryng et al. (2013). Disentangling uncertainties in future crop water productivity under climate change. *PNAS, in review.*
Effects of climate change productivity changes on agricultural prices
(S3-S6 results in 2050 relative to S1 results in 2050)

Source: AgMIP model runs, December 2012.

There is potential for large price increases with climate change, although uncertainty is also large
### Ag-GRID Workplan

#### Phase 1: Historical evaluation
- Year 2013
  - Quarter 2
  - Pre-planning: Q1
- Year 2014
  - Quarter 1
  - Simulation: S1
  - Analysis: A1
  - Publication: P1
- Year 2015
  - Quarter 3
  - AG4

#### Phase 2: CTWN Analysis
- Year 2014
  - Quarter 2
  - Planning: P2
  - Simulation: S2
  - Analysis: A2
  - Publication: P2
- Year 2015
  - Quarter 4
  - SM1
  - AG5

#### Phase 3: Coordinated assessment
- Year 2016
  - Quarter 1
  - Planning: P3
  - Simulation: S3
  - Analysis: A3
  - Publication: P3
- Year 2017
  - Quarter 2
  - SM2
  - COP
  - A5
  - SM3

#### Other activities
- Year 2015
  - Quarter 3
  - IT and data: D1
  - RAP Scenarios: S1
- Year 2016
  - Quarter 4
  - E2
  - E3
Phase I: Historical evaluation

- Nine reanalysis-based historical weather products spanning 1948-2012
- Harmonized on fertilizer, sowing, maturity, etc.
- Additional focus on large-scale extreme drought/heat events in the historical record.
Future phases

• Phase II: CTWN
  – Multi-dimensional sensitivity study of model response to carbon, temperature, water, and nitrogen.

• Phase III: Coordinated assessment
  – Vulnerabilities, impacts, and adaptations
  – New set of future climate forcings from CMIP5 and CORDEX
  – Detailed set of adaptation scenarios developed in the AgMIP Representative Agricultural Pathways (RAPs) framework
  – Contribution to IPCC AR6
Papers coming out soon


1. Historical analysis of model and ensemble hindcasting skill;
2. Agro-climatic analysis of the relative import of different methods for developing climate forcing datasets (reanalysis models, bias-correction technique, and target datasets; from the priority 2.1 “Climate Track” simulations);
3. A summary of Phase 1 results for priority 2 crops (from the priority 2.2 “Crops Track” simulations).
4. A detailed assessment of all national- and continental-scale extreme climate events in the historical record, and the ability of models to reproduce the agricultural impacts of these events.
5. Sensitivity of simulated crop yields to the ET0 equation used within the crop model, which has been identified as a priority model process difference to evaluate and understand in Phase I. Preliminary results, obtained using pDSSAT run with both Penman-Monteith and Priestley-Taylor ET equations, show a difference in simulated yield up to 30% in some regions (most notably in rainfed systems in arid regions.
6. Variability from models, weather, …
To participate, share data, etc. . . .

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Integrating GGCM results

- Hotspots

Piontek et al. 2013
Climate, Irrigation, and Adaptation

Compare within and among ensembles of water supply and demand (and yield with/without irrigation) projections from 11 global hydrological models (GHMs) and 6 global gridded crop models (GGCMs) driven by climate change scenarios from 5 GCMs under RCP8.5.

Source: Elliott et al. (2013). Constraints and potentials of future irrigation water availability on global agricultural production under climate change. PNAS, in press.

GHMs show large increase in irrigation use,
GGCMs with [CO2] effects show reduction in overall demand.
Global Economics Models

Effects of climate change on agro-economic variables
(9 global econ models, 5 GGCMs, and 2 GCMs/2050s)

There is potential for large price increases with climate change, although uncertainty is also large

Nelson, Gerald C. et al., “Climate change effects on agriculture: Economic responses to biophysical shocks.” *PNAS, in press*