AgMIP The Agricultural Model Intercomparison and Improvement Project

High-resolution climate information needed for agricultural modeling applications

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➢ What’s needed from climate data/models:

- Scales ranging from 1 m^2 to 0.5°x0.5° grids
- Resolution of agricultural land response (as distinct from broader grid box)
- Improved statistics of high-resolution processes over long time scales
- Accurate seasonal timing for connections with crop development
- Focus on how characteristics change with anthropogenic climate change

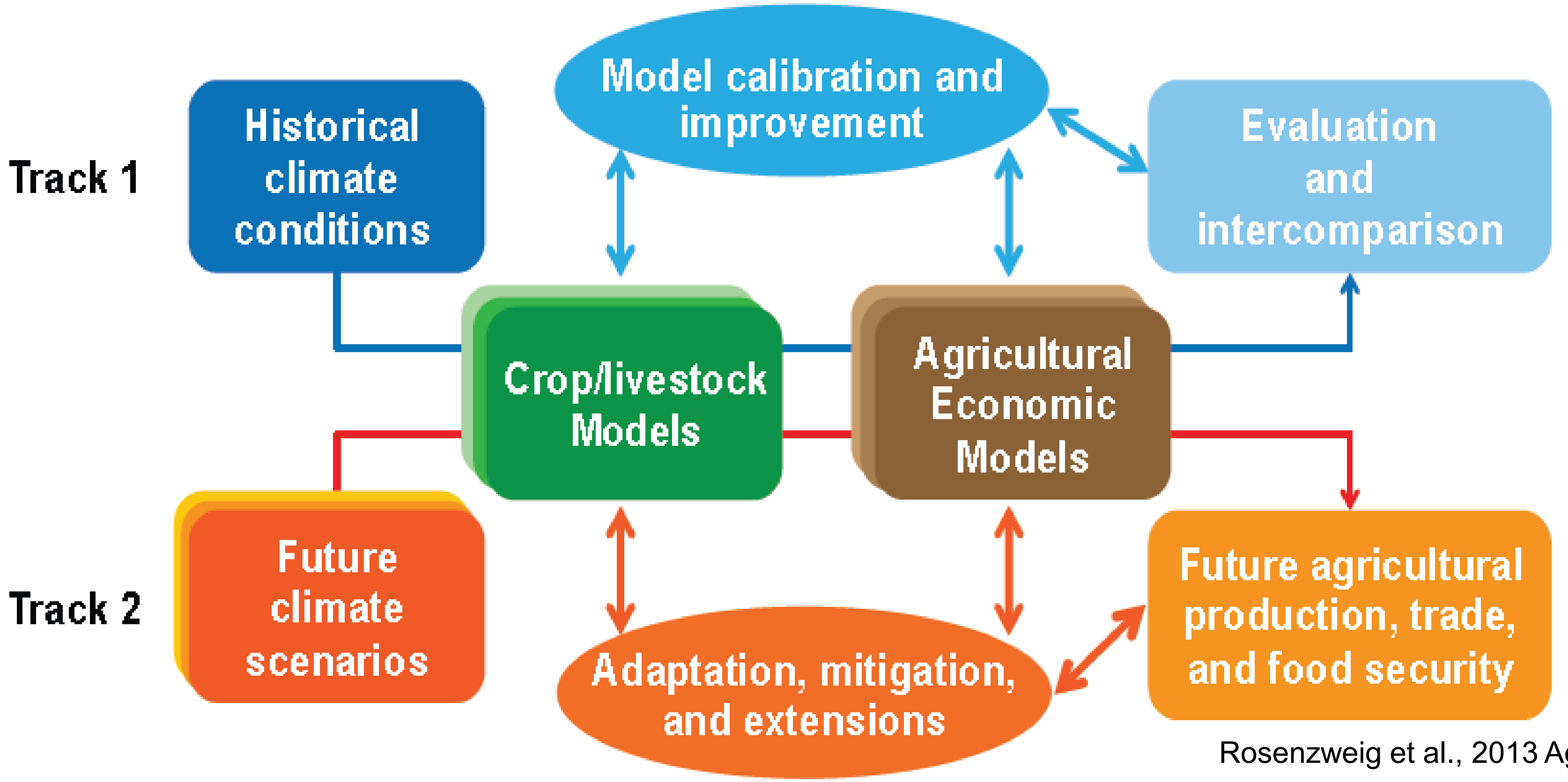
- Distributions of temperature and rainfall including extreme tails
  - Hourly, daily, seasonal statistics
  - at interannual, decadal, and climate change time scales
- Evapotranspiration, vapor pressure, relative humidity
- Soil moisture at several layers (down to 2m)
- Canopy wetness and wind vectors
- Wind gusts (2m height)
- Hail
- Direct/diffuse radiation

What’s needed ≠ What’s available ≠ What’s useable


The Agricultural Model Intercomparison and
Improvement Project (AgMIP)

The Agricultural Model Intercomparison and Improvement Project

Rosenzweig et al., 2013; Agricultural and Forest Meteorology



Rosenzweig et al., 2013 AgForMet

Track 1: Model Improvement and Intercomparison

Track 2: Climate Change Multi-Model Assessment

AgMIP is an international community of ~780 **climate scientists**, **agronomists**, **economists**, and **IT experts** working to improve assessments of **future food security; 30+ activities**

Overview of AgMIP Approach

AgMIP Climate Team has three main areas of focus:

- **Historical period climate datasets** – sensibility analysis, validation, basis for downscaling

- **Sensitivity of agricultural production to climate changes** – relative response to key shifts in mean, variability, and extremes

- **Future period climate scenarios** – enable probabilistic, consistent, understandable scenario-based analysis

AgMIP assessments challenges:

- Practical number of simulations
- Cross-cutting themes: Aggregation and scaling; Uncertainty

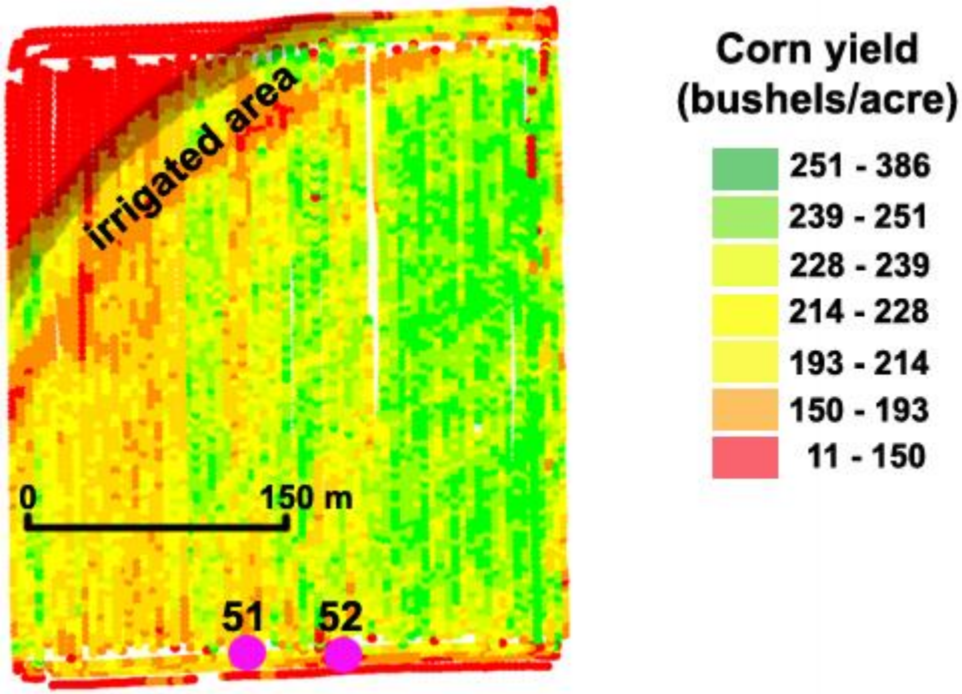

Climate Information needed across
a range of scales

Agricultural Models Applied at 1 m^2 scale for precision agriculture

Crop models require:

Daily climate series (Tmax, Tmin, Precip, Solar Radiation), soils, management, and cultivar information

More information needed for specific applications (Evapotranspiration, pests/diseases)

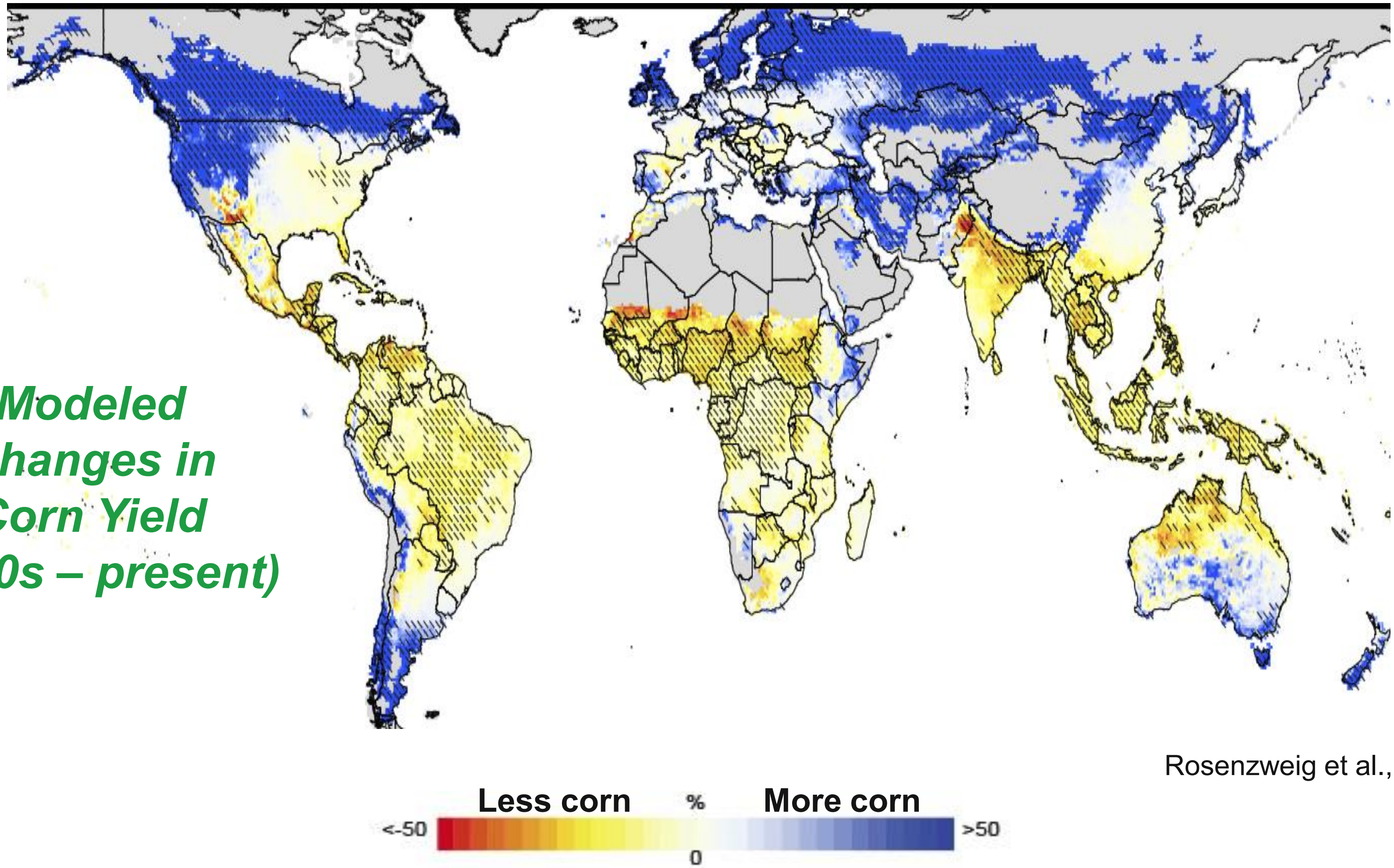


Harper and Hartke, Indiana Geological Survey:
http://igs.indiana.edu/Groundwater/JacksonCounty.cfm

Drones used for soil moisture and heat anomalies as well as vegetation indices

Global Gridded Crop Models 0.5º x 0.5º and finer in regions (5’x5’)

Modeled Changes in Corn Yield (2080s – present)



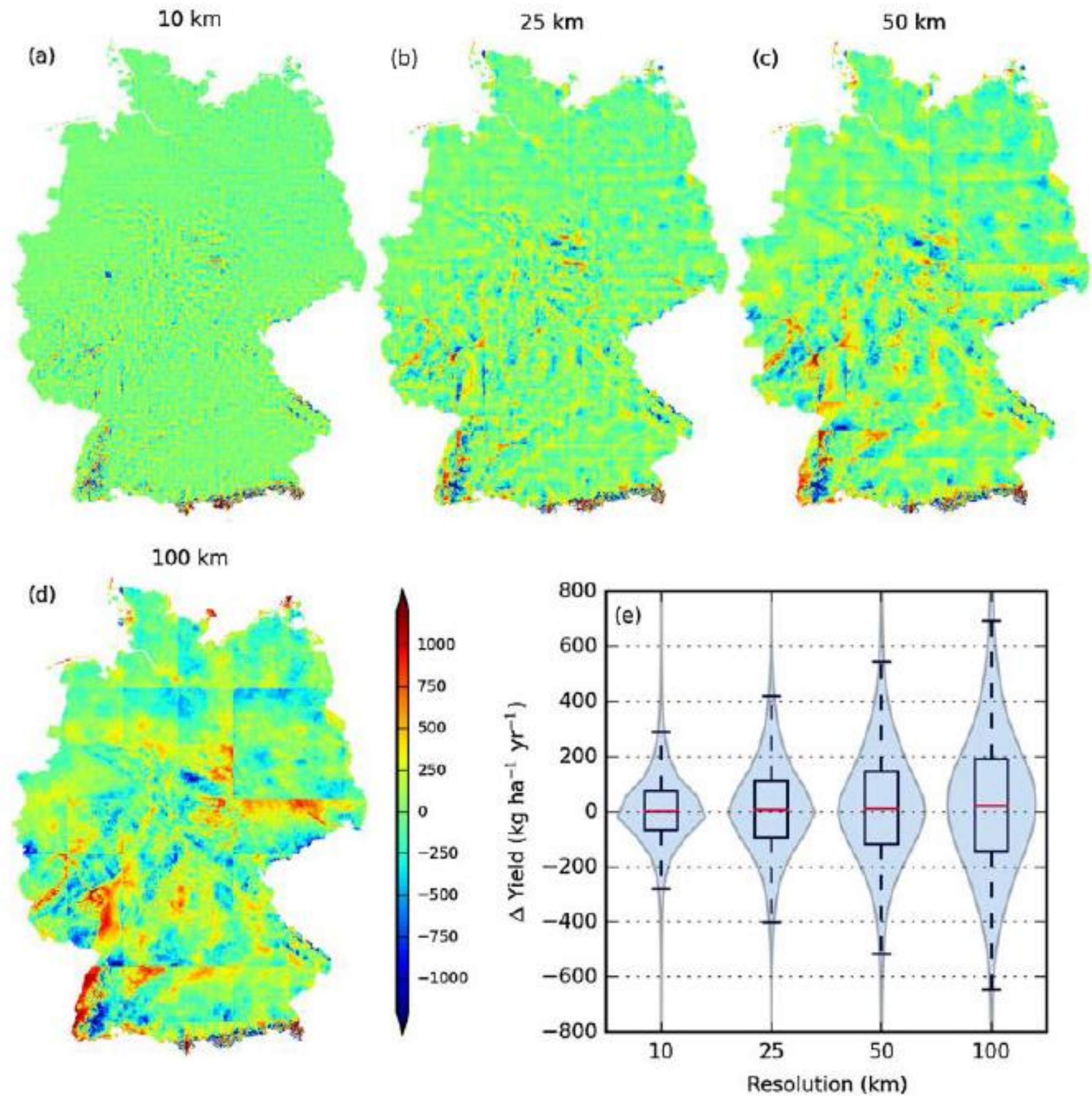
Rosenzweig et al., 2013

5 GCMs, 7 GGCMs; hatched = 70% agreement in sign of change

Aggregation and Scaling

Zhao et al.,2015

➢ **AgMIP Aggregation and Scaling Pilot (led by Frank Ewert) compares the effect of high-resolution climate, soils, and management on yield outcomes.**

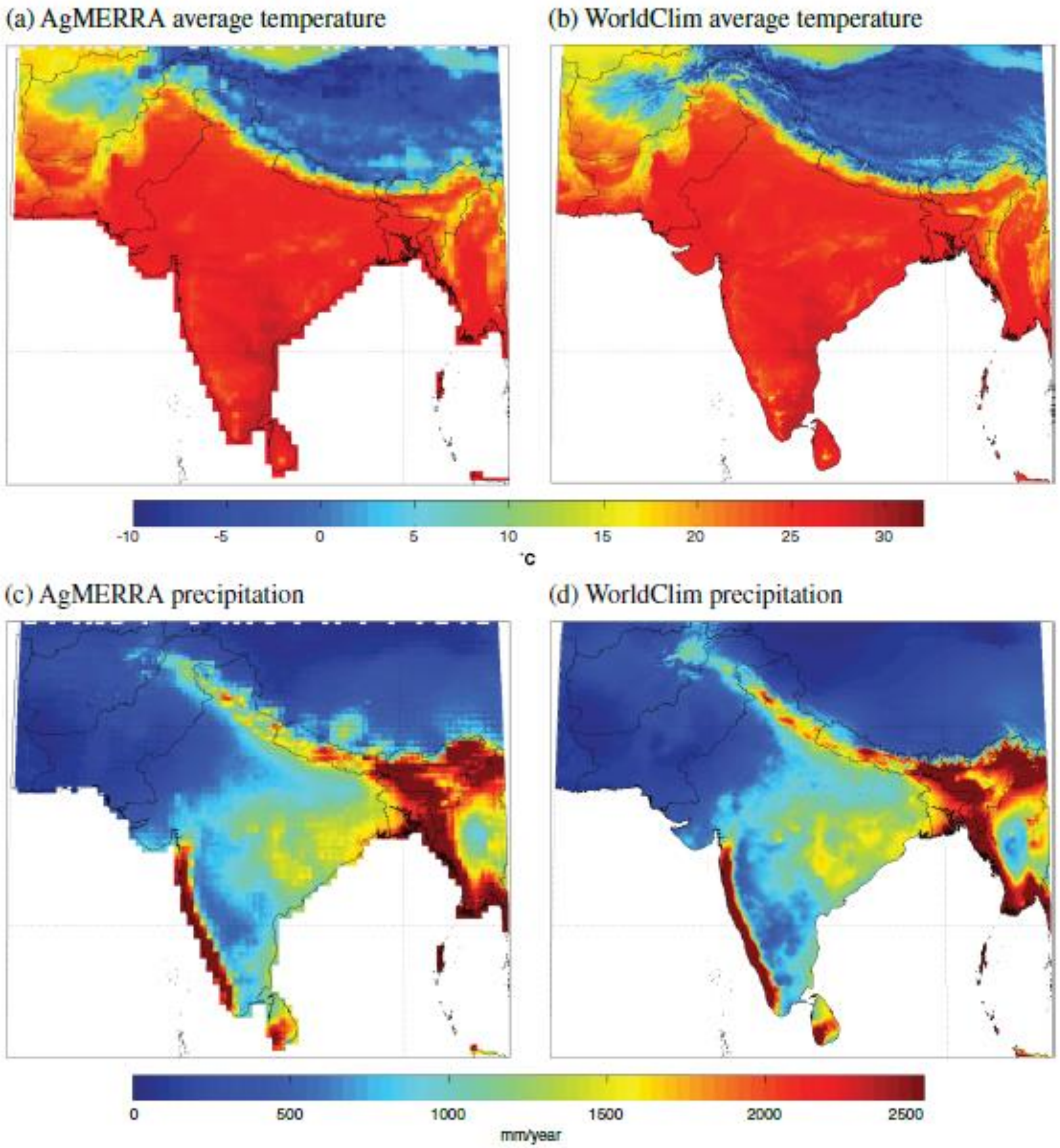


Estimating Fine-scale Differences in Regional Farms' Climate

Regional Integrated Assessments

Ruane et al.,2015; Climate Change and Agroecosystems, Volume 3 Part 1

- **Utilize ~1000 farm locations from economic survey (~30x30km region)**
- **Need to represent potential for difference between farms from local climate**
- **Currently seed variability from local weather station and then estimate nearby stations using deviations from WorldClim (Hijsmans et al., 2005)**



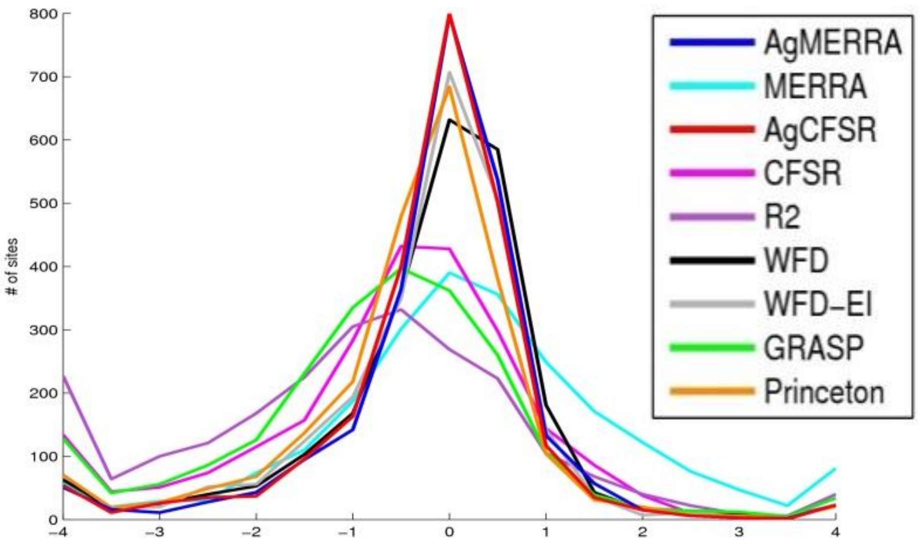
Historical-period Climate Forcing Datasets

Sensibility Analysis and Target for Downscaling

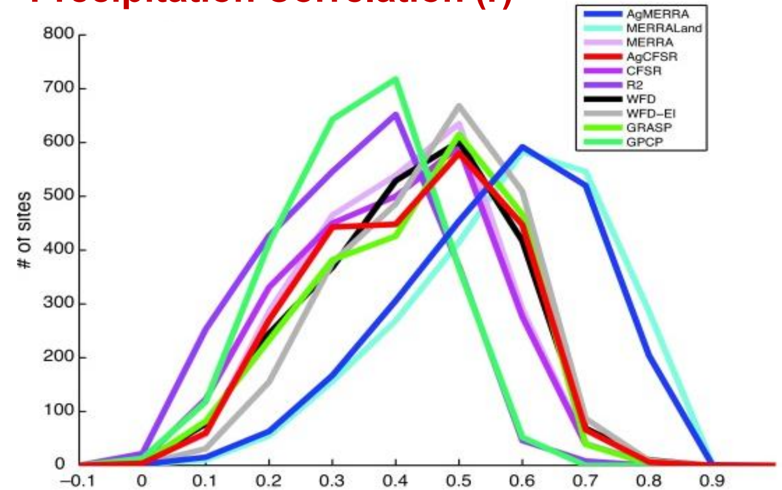
AgMERRA Historical Climate Data

Ruane et al., 2014; Agricultural and Forest Meteorology

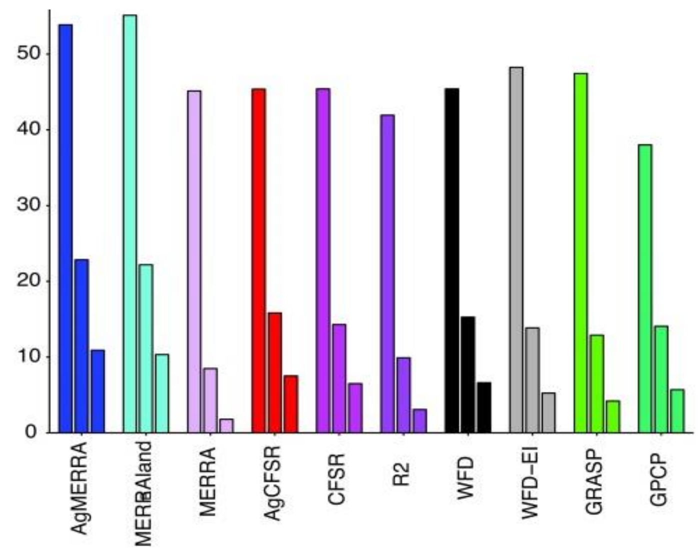
Avg of Tmax and Tmin Biases (° C)



Precipitation Correlation (r)



Threat score for 1, 25, and 50mm precipitation events (%)



AgMERRA features:

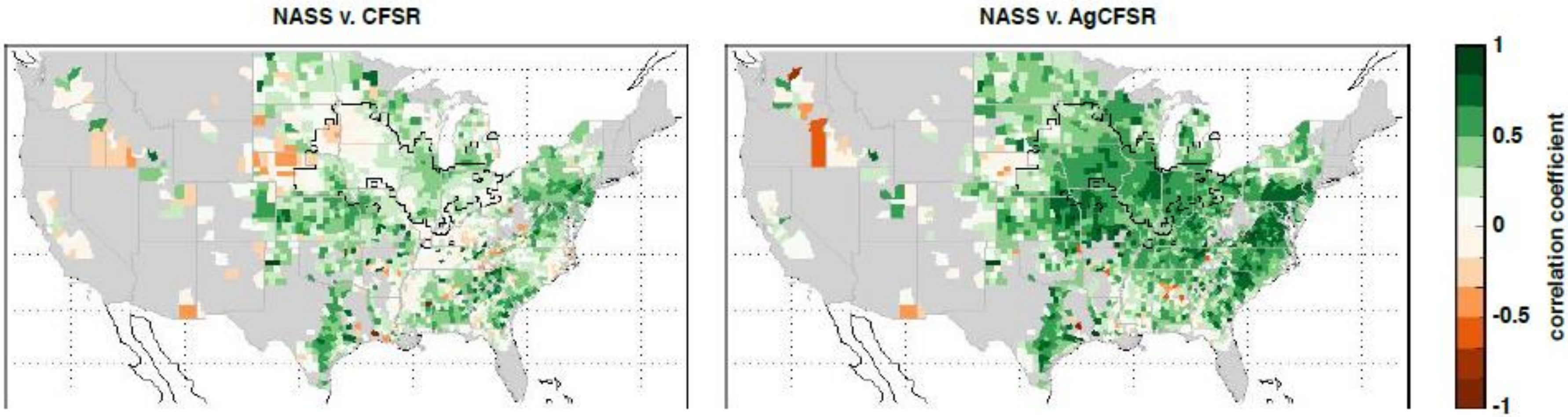
- **improved solar radiation**
- **Improved precipitation variability**
- **fine spatial patterns of rainfall from satellites**
- **an adjustment to diurnal temperature range**
- **relative humidity at Tmax**

AgMERRA better captures rainfall distribution and actual sequence of extreme events

Other data to integrate: DayMET, PRISM, CHIRPS, PERSIANN/CMORPH/TRMM, …

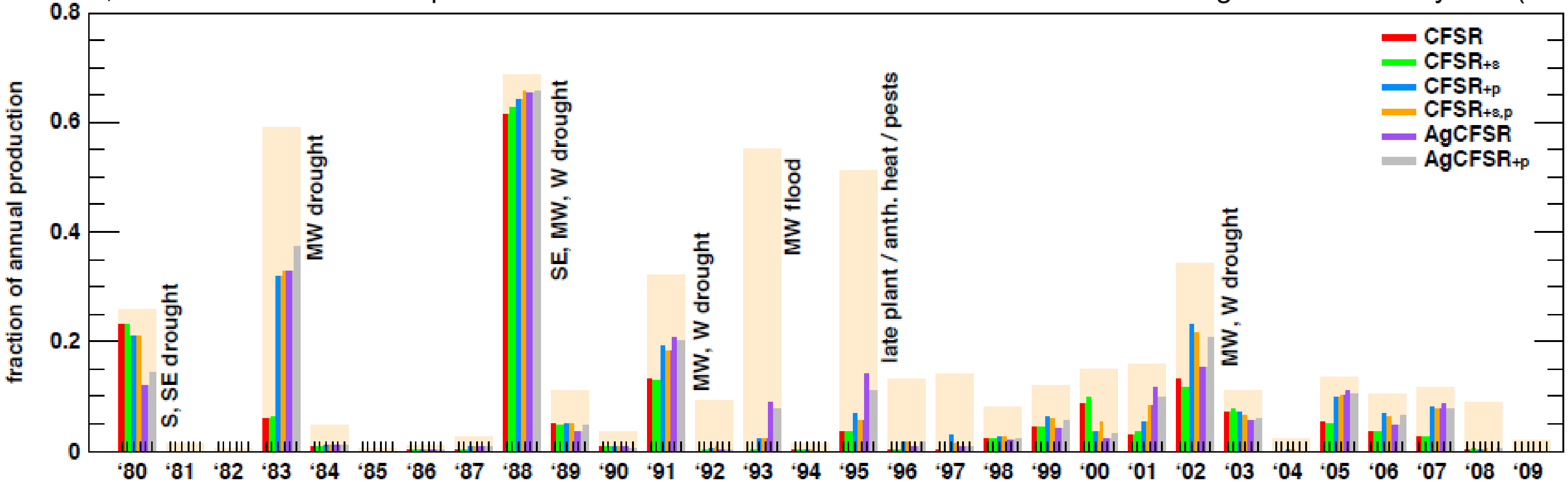
AgCFSR vs. CFSR in US Maize

Glotter et al., in review



Above: Correlations between NASS County-level production and that simulated by pDSSAT using CFSR (left) and AgCFSR (right) climate data (from Glotter et al., in preparation)

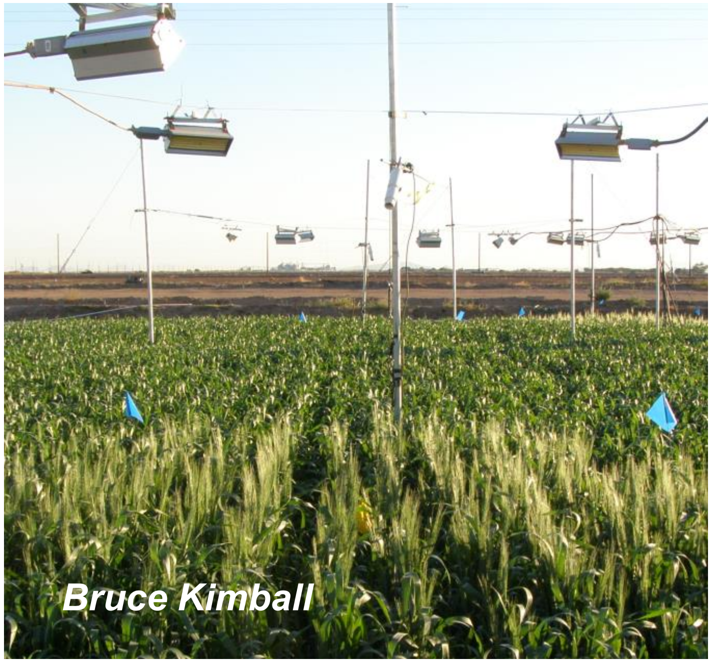
Below: Probability of detecting extreme events. Tan bar shows fraction of US maize production experiencing one of 5 worst years in NASS data, each colored bar is the production from the same counties that is simulated as being in one worst 5 years (Glotter et al.)

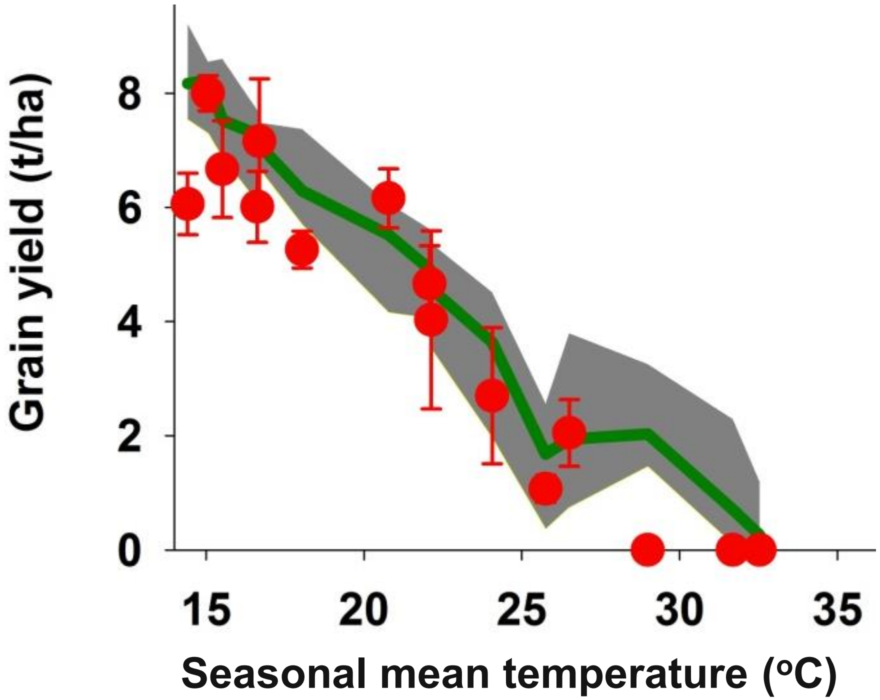


Improving Simulated Response to Climate Changes

The need for a receptive impact model

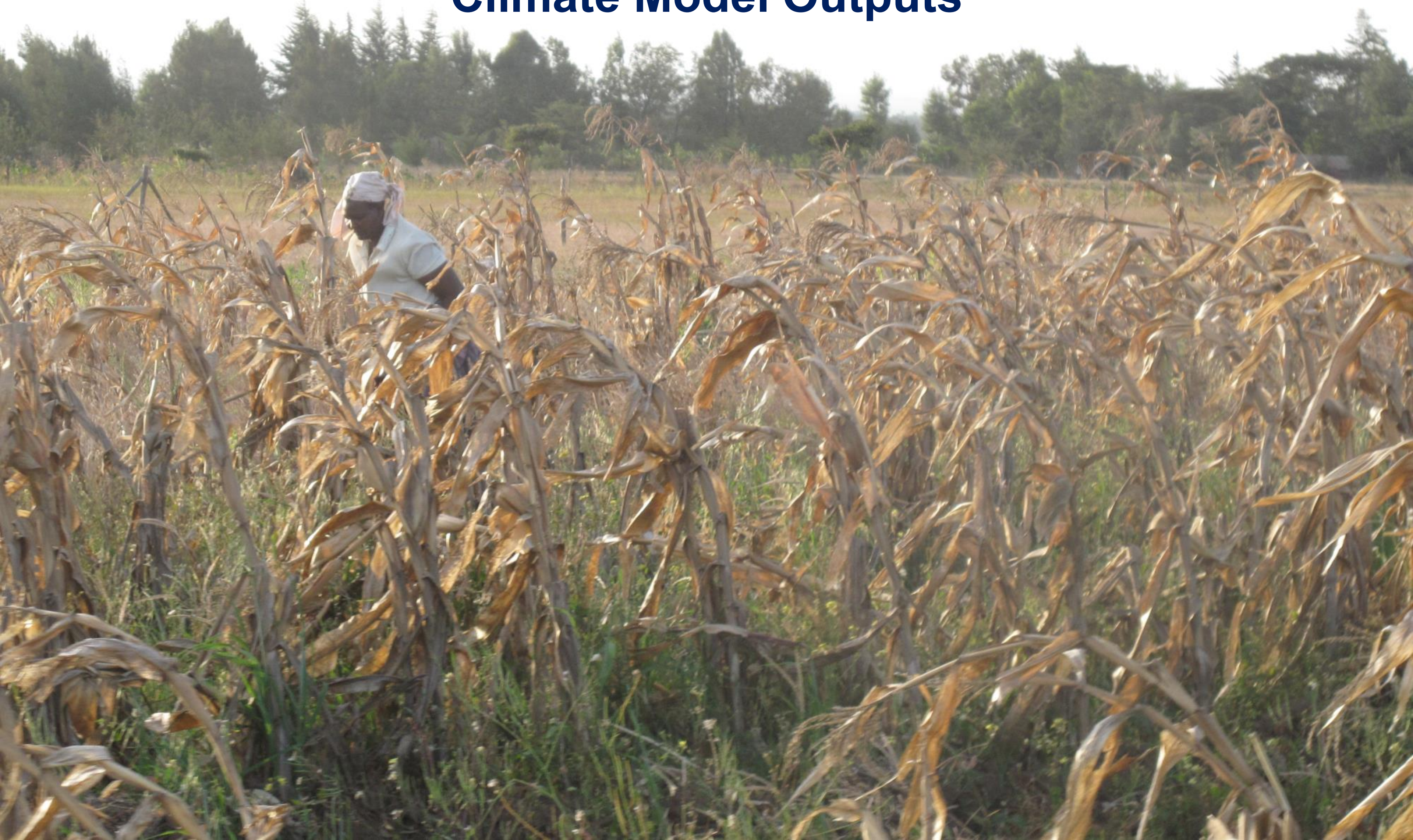
- The AgMIP Wheat Team compared 30+ wheat models against field trial data from the Hot Serial Cereals experiment in Maricopa, Arizona.
- In many AgMIP studies the response to climate change is quite consistent despite lingering mean yield biases
- Not worth downscaling effort if impact model is not responsive to higher-resolution information





Looking toward the future:

Climate Scenarios and Dynamically-downscaled Climate Model Outputs



Common Approaches and Challenges for Future Scenarios

Mixing and Matching – Agricultural model applications are unique in that many do not require spatial coherence; allows for mixing and matching of products that add value.

Weather Generators – synthesize weather series utilizing basic information from climate models about variable distributions and relationships

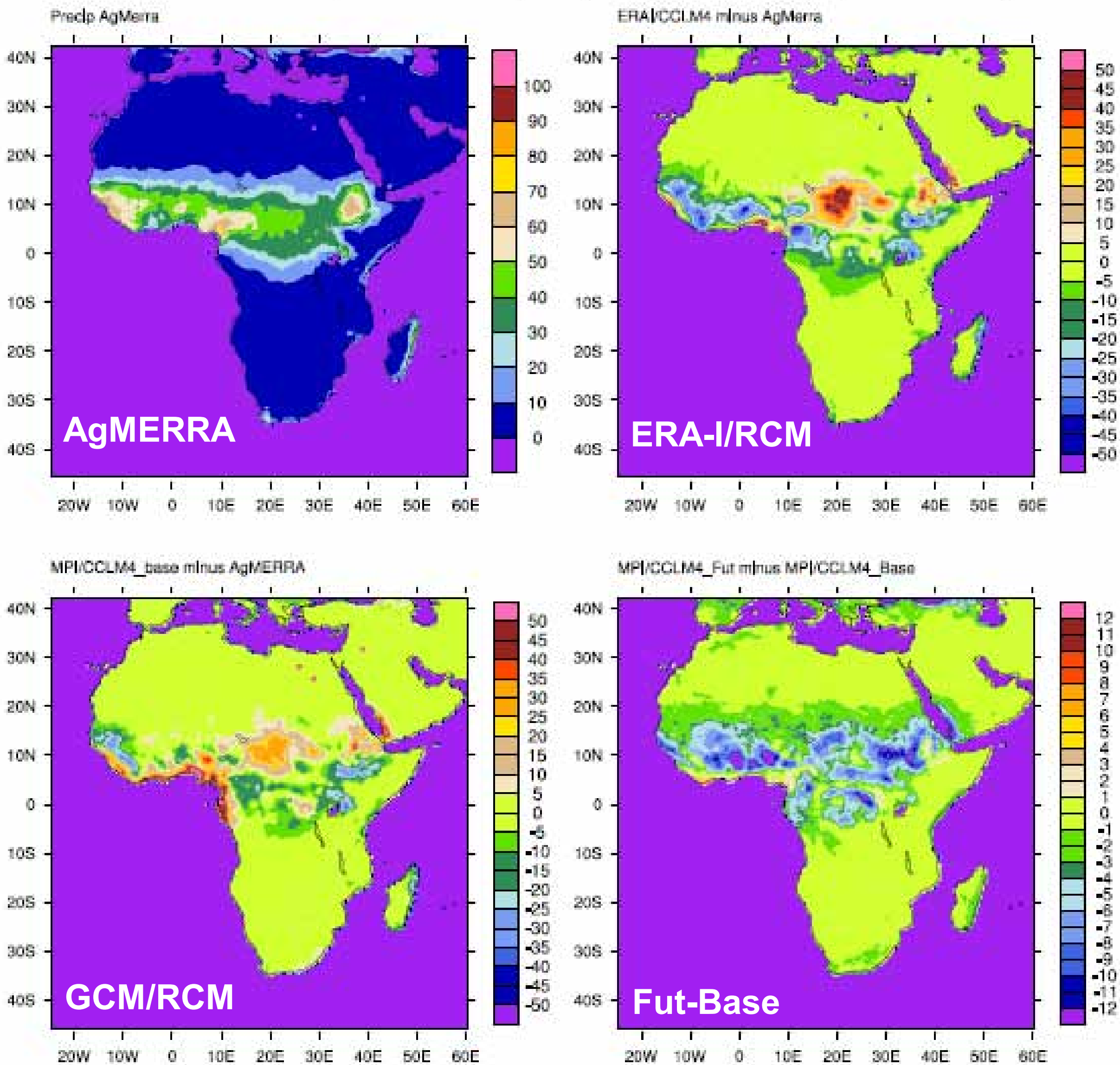
Need for subsets – huge number of combinations possible:
GCM x RCP x SSP/RAP x Crop Model x Economic Model x Adaptation
(difficult to add various downscaling approaches here)

Enhanced Delta Approach – quantile mapping from observations based upon changes in fitted distributions

Many groups applying RCMs or statistical approaches blindly

Dynamical Downscaling

Seasonal Precip 5mm Rainy Day 30yrs June-Sep (1976-2005)



- **Tremendous potential of downscaled climate models**
- **Simulations at scales capable of better resolving extreme events and fine-scale patterns**
- **Need to simulate historical conditions sensibly but then information comes from simulation of climate changes**
- **CORDEX appealing due to international consistency**

- **Difficult to obtain all results from CORDEX**
- **Need more analyses of strengths/weaknesses**
- **Important to justify mean changes from GCM**

Concluding Thoughts

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Concluding Thoughts

- AgMIP and related projects are conducting several activities that would be aided by accurate high-resolution climate information
  - Process understanding more useful than higher resolution of outputs

- Need better historical period data to form a sensible basis for downscaling.

- Need to align efforts in downscaling with receptive impact models and practical applications
  - Lots of ongoing work to improve ag model response to extremes

Also:

- AgMIP is planning a Coordinated Global and Regional Assessment of Climate Change Impacts on Agriculture and Food Security with an aim to inform the IPCC Sixth Assessment Report.


Thanks!
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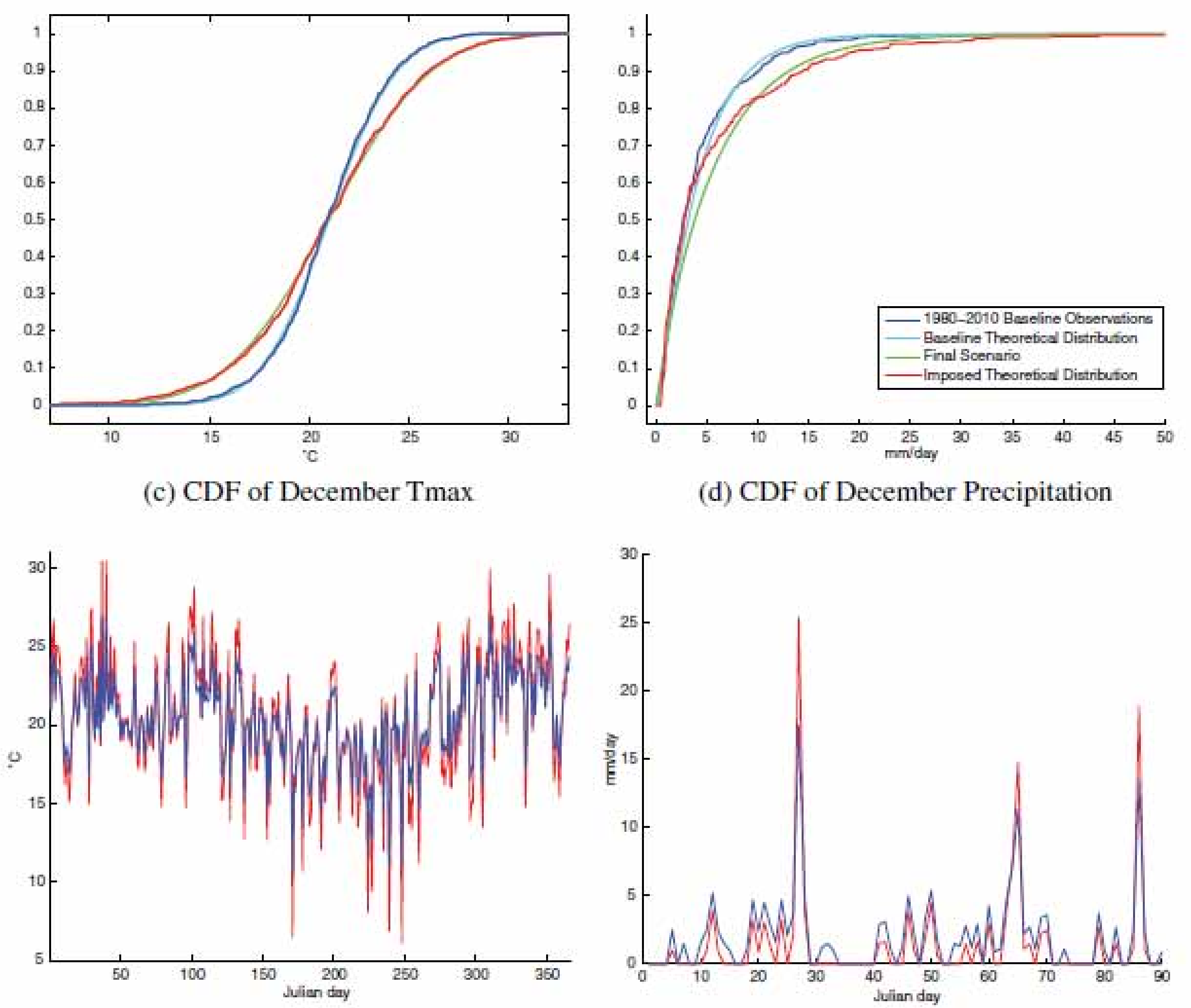
Current AgMIP Activities

Rosenzweig et al., 2015; Climate Change and Agroecosystems, Volume 3 Part 1

Visit www.agmip.org for more information and to sign up for AgMIP listserv

Enhanced Delta Method



(c) CDF of December Tmax

(d) CDF of December Precipitation

(e) Mean and Variability ΔT Example

(f) Mean and Variability ΔP Example

Recognizable historical time series adjusted to impose climate changes drawn from CMIP5 models.

Adjusts each month's:

- Mean Tmax, Tmin
- Standard deviation of daily temperatures
- Mean precipitation
- # rainy days
- Shape of rainfall distribution

Does not adjust:

- Solar radiation
- Wind speed
- Relative humidity at Tmax (although vapor pressure and VPD changes)

GCM Δvariability is less reliable than Δmeans

Shizukhuishi, Japan, hypothetical scenarios from Ruane et al., 2015