AgMIP The Agricultural Model Intercomparison and Improvement Project

Representing Extremes in Agricultural Models




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CENTER FOR CLIMATE SYSTEMS RESEARCH
THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY

AgMIP The Agricultural Model Intercomparison and Improvement Project

Extreme events on agricultural systems

➢ Driven by climate extremes

- Heat waves
- Floods
- Wind/hail damage
- Frosts
- Water logging
- All depend on seasonal timing with phenology
- Many depend on conditions at the start of the season

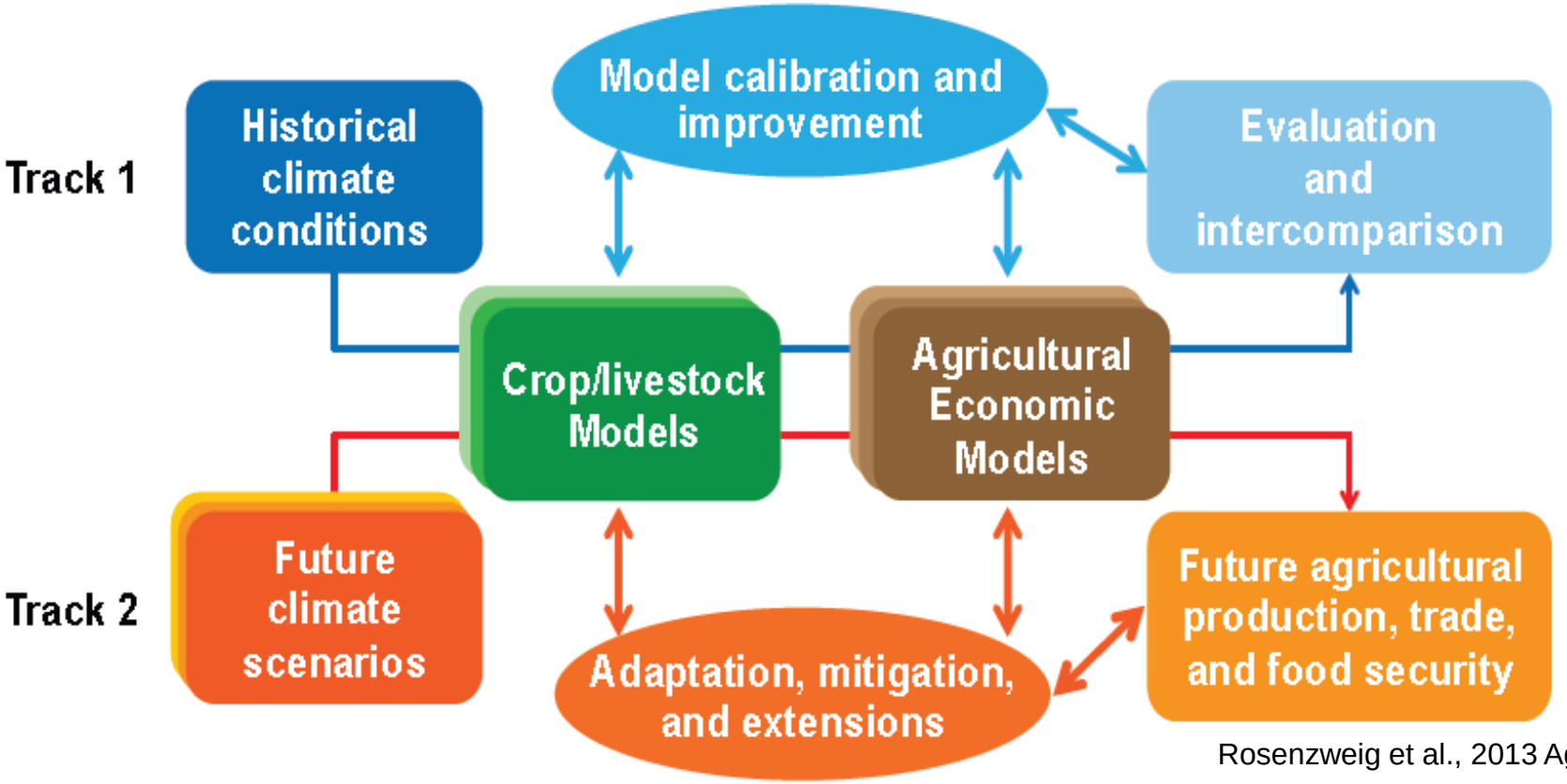
➢ Driven by outbreaks of pests, diseases, weeds

- Also largely dependent on climate; particularly temperature, canopy wetness and wind vectors

➢ Driven by socio-economic factors

The Agricultural Model Intercomparison and Improvement Project

Rosenzweig et al., 2013; Global Change Biology



Rosenzweig et al., 2013 AgForMet

Track 1: Model Improvement and Intercomparison

Track 2: Climate Change Multi-Model Assessment

AgMIP PIs: Cynthia Rosenzweig, Jim Jones, John Antle, Jerry Hatfield

AgMIP Leaders: Climate (Alex Ruane, Sonali McDermid), Crop/Livestock Modeling (Ken Boote, Peter Thorburn), Regional Economics (John Antle, Roberto Valdivia), Global Economics (Keith Wiebe, Hermann Lotze-Campen), IT (Cheryl Porter, Sander Janssen)

Current and Prospective Activities

Rosenzweig et al., 2015

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

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

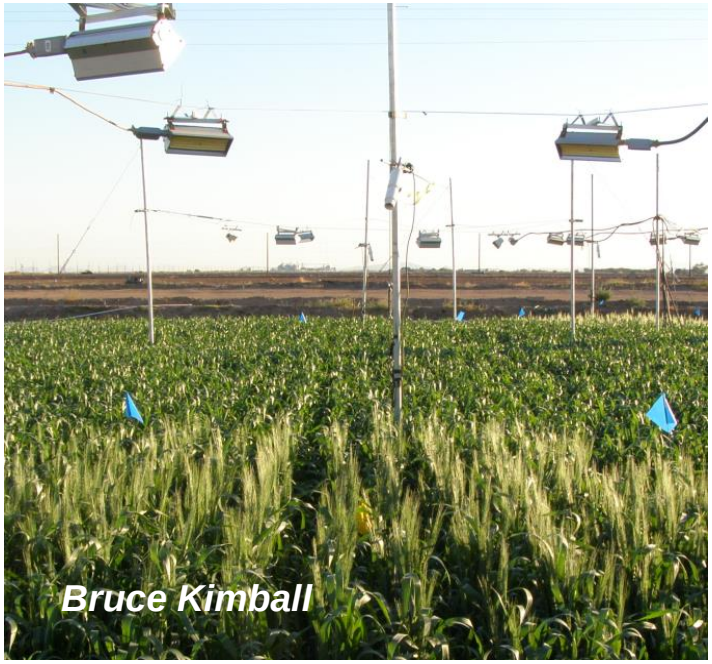
Wheat response to temperature extremes

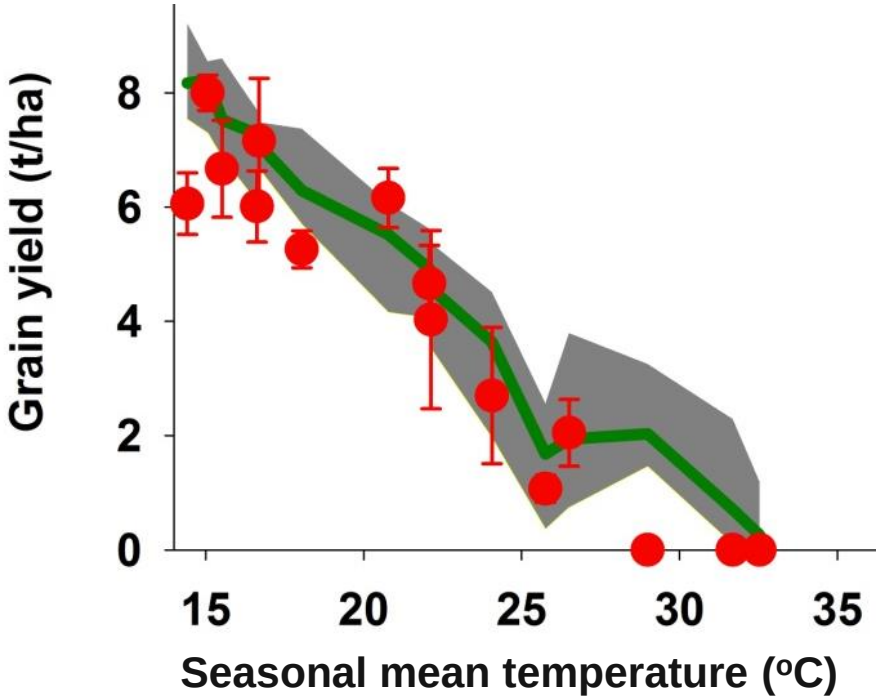
Asseng et al., 2014; Nature Climate Change

- **The AgMIP Wheat Team compared 30+ wheat models against field trial data from the Hot Serial Cereals experiment in Maricopa, Arizona,**

- **Also examined CIMMYT trials of heat extremes.**

- **Emphasis now on model improvement for heat spike responses, particularly during anthesis**

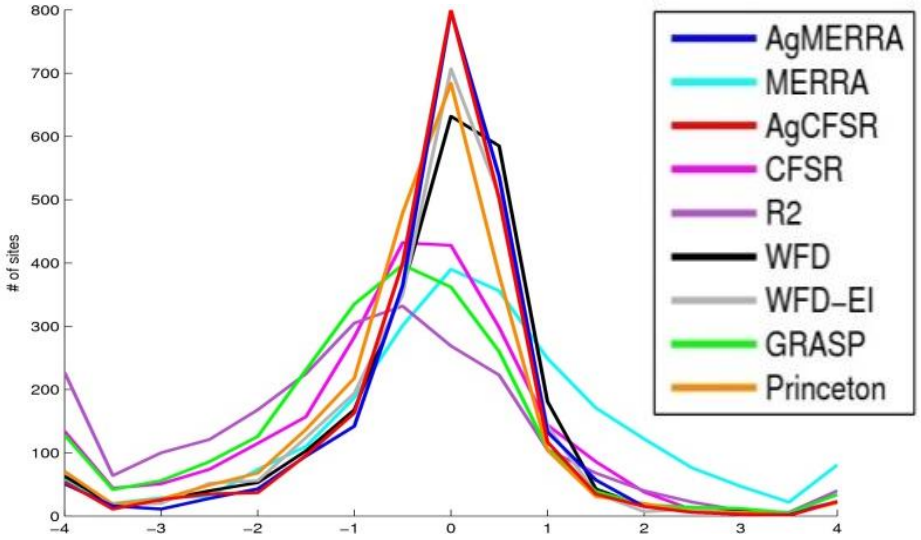




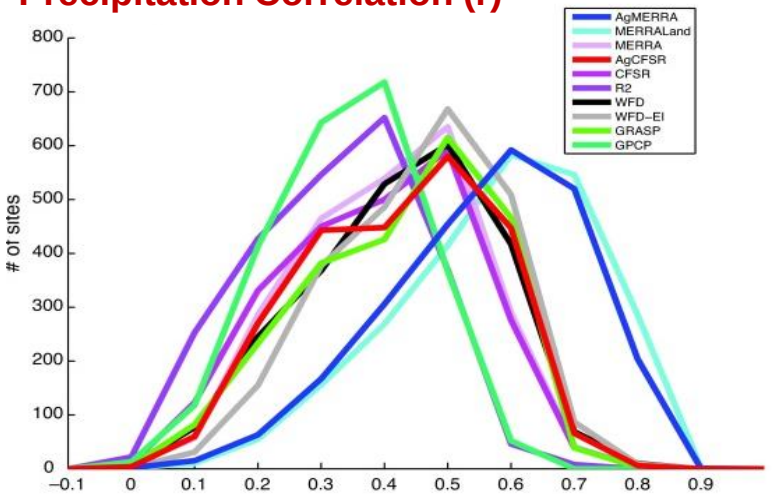
AgMERRA Historical Climate Data

Ruane et al., 2014; Agricultural and Forest Meteorology

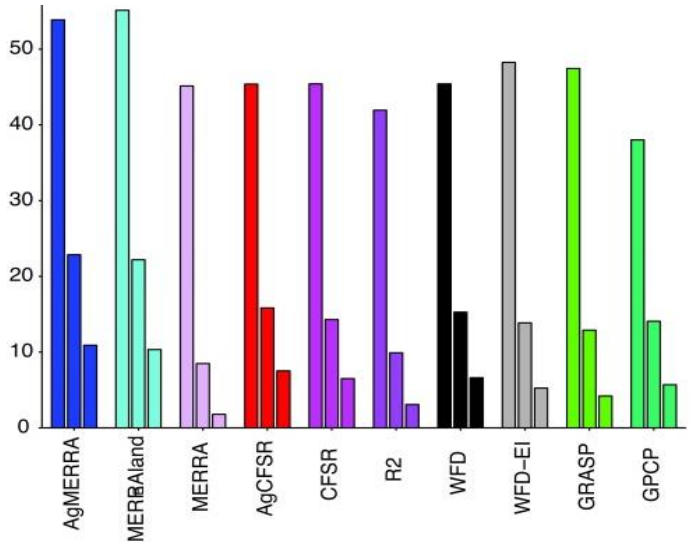
Avg of Tmax and Tmin Biases (°C)



Precipitation Correlation (r)



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



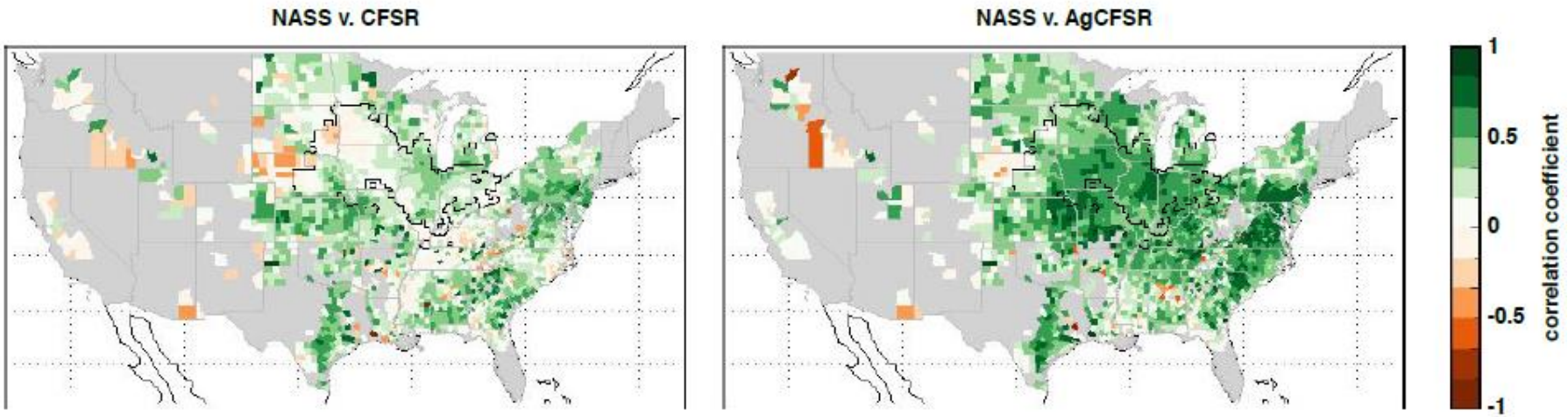
AgMERRA features:

- 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

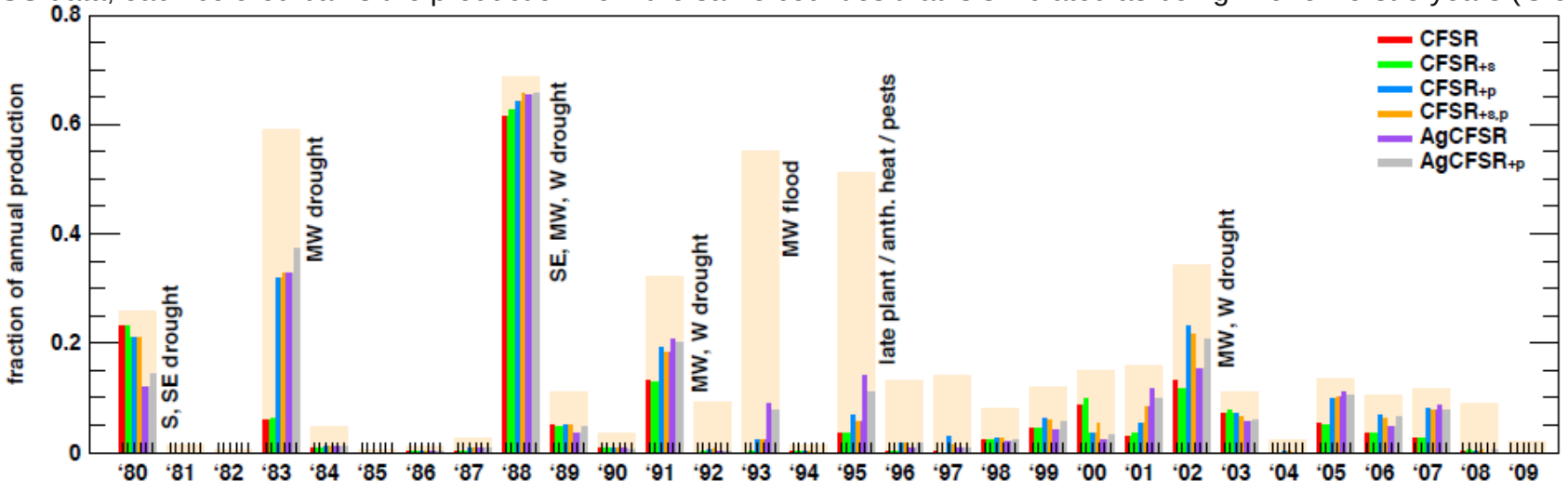
AgCFSR vs. CFSR in US Maize

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)

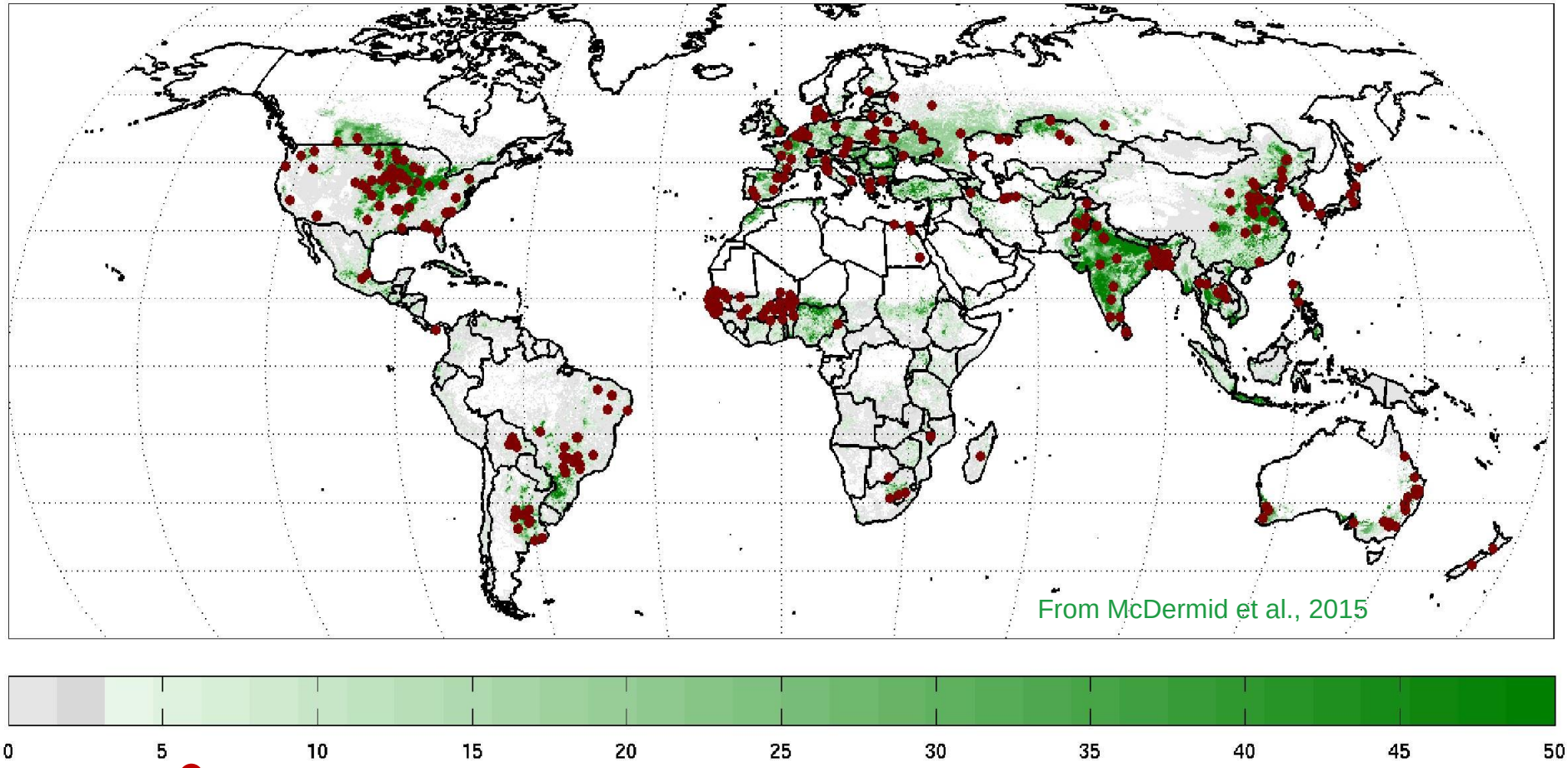
Below: Probability of detecting extreme events. Tan bar shows fraction of US maize production experiencing one of 5 worst years in NASS data, each colored bar is the production from the same counties that is simulated as being in one worst 5 years (Glotter et al.)



Sites included in AgMIP's Coordinated Climate-Crop Modeling Project

McDermid et al., 2015

All C3MP Submitted Sites and Major Croplands (Percentage Area)



● C3MP submitted site (1084 simulation sets shown – archive as of 09/01/2014)

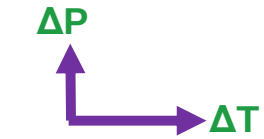
Green = fractional crop land area data from Monfreda et al. (2008)

Now over 1100 simulation sets
>50 countries
16 crop species; 18 crop models

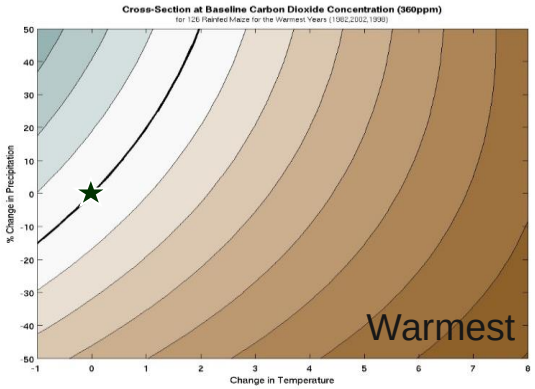
Driest and warmest years most sensitive to changes in rainfall and temperature

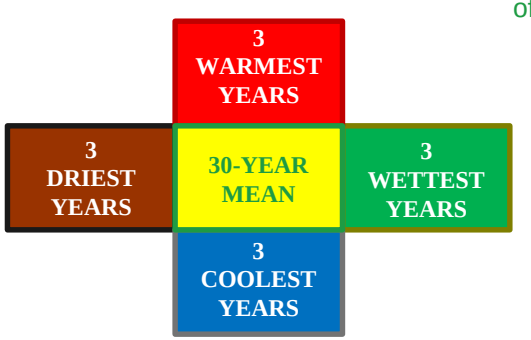
Ruane et al., in prep

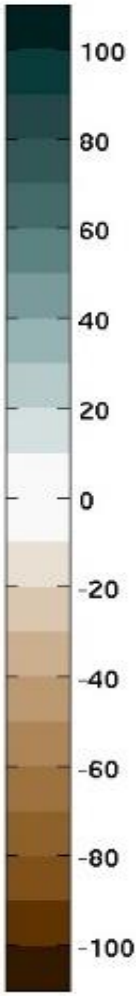
Response of 126 C3MP Maize Sites to:

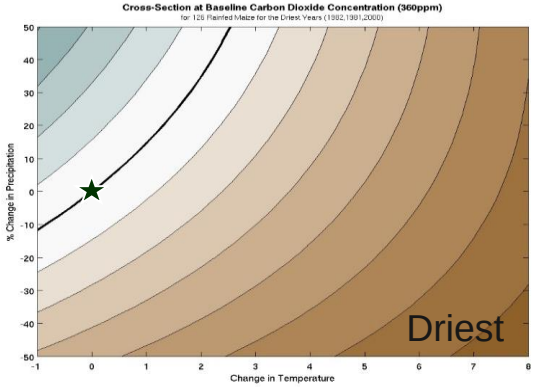


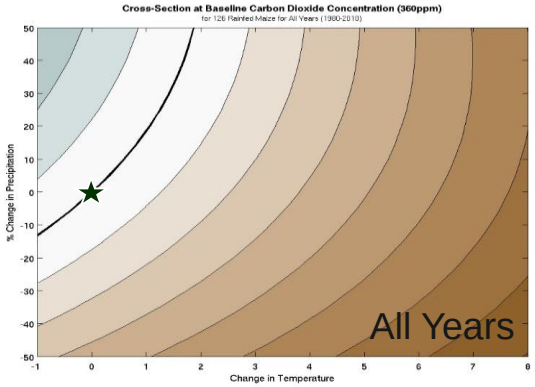
$[CO_2]$ = 360ppm

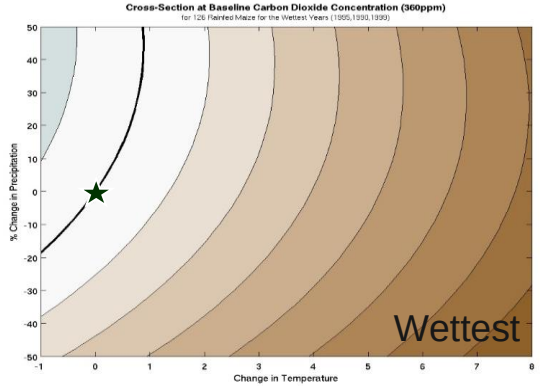


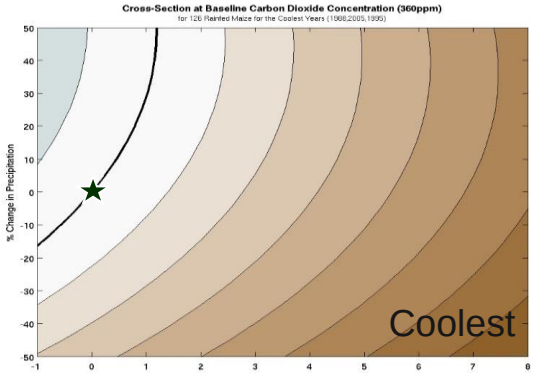












Driest and warmest years most sensitive to changes in [CO_2] and temperature

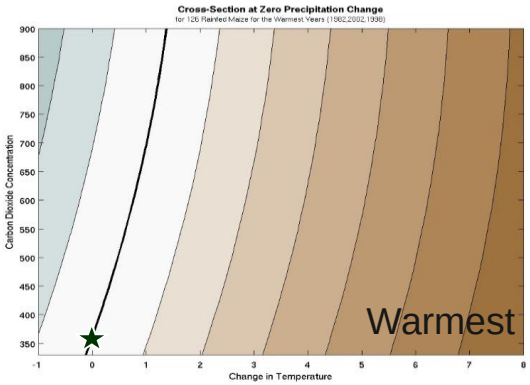
Ruane et al., in prep

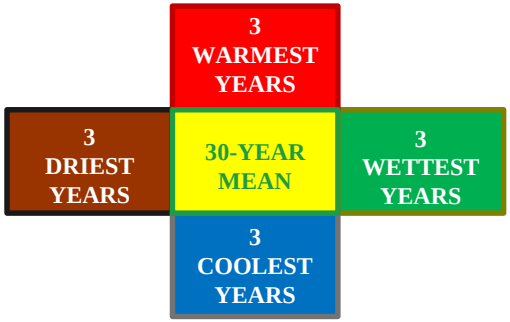
Response of 126 C3MP Maize Sites to:

[CO_2]

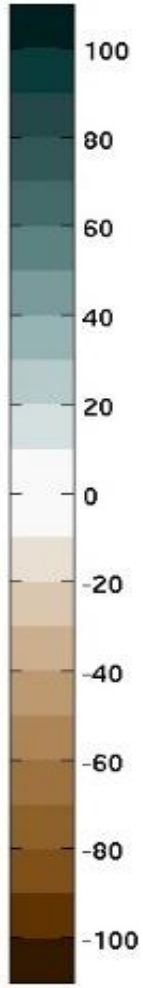
ΔT

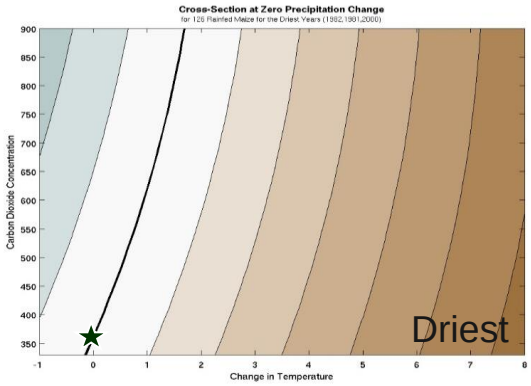
ΔP = 0%

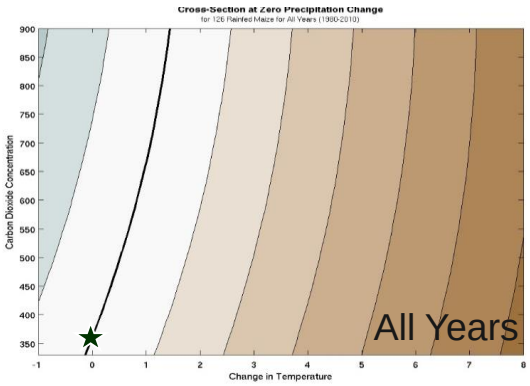


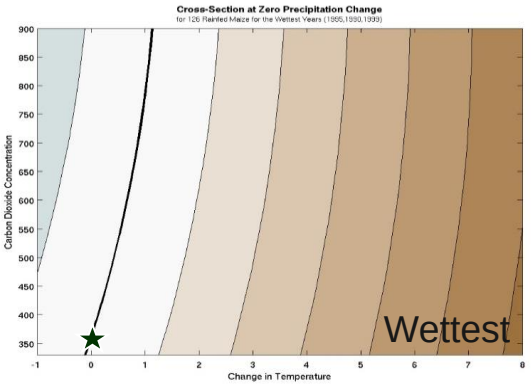


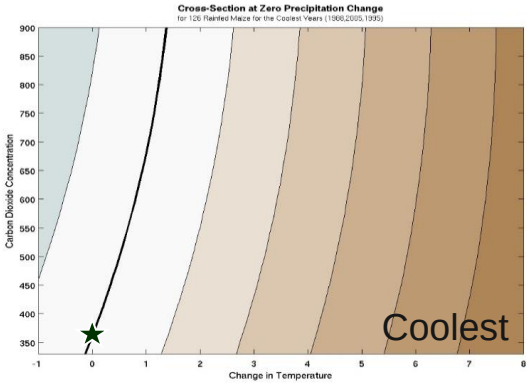
Yield Change (% of baseline mean)







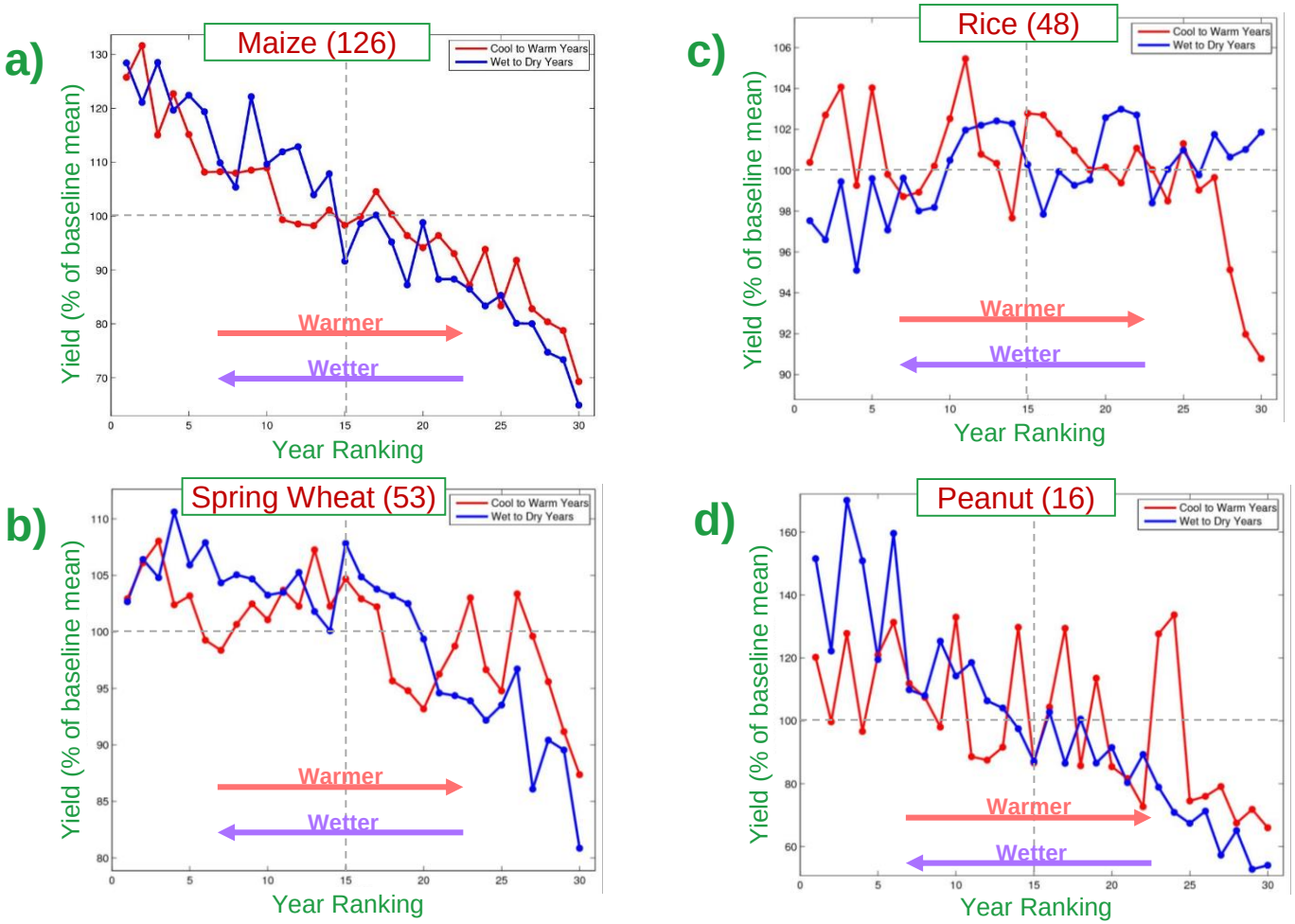




Capturing curvature of response to extreme events in historical simulations

Ruane et al., in prep

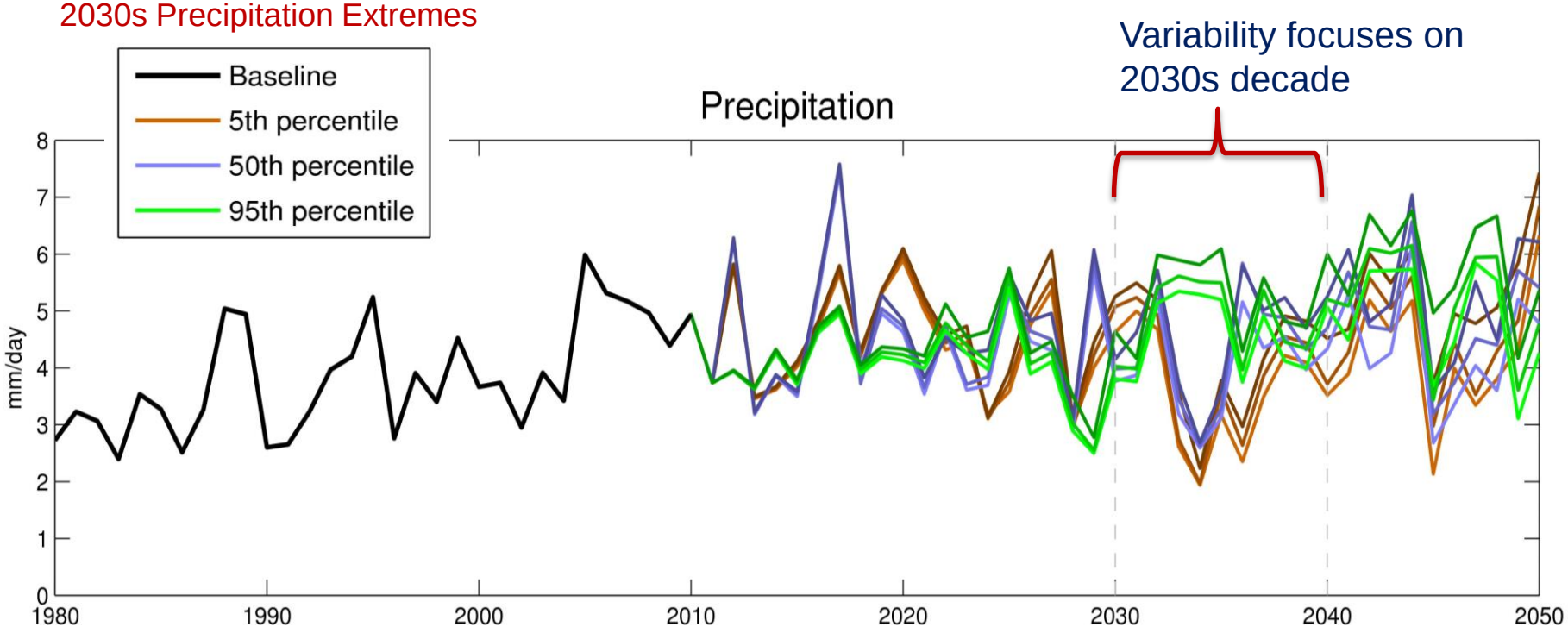
➢ **By ranking all C3MP rain-fed sites according to warmest and wettest years from 1980-2010, we can see basic patterns of response to extremes.**



Constructing Near-term Climate Scenarios with focus on Extremes

Ruane and Greene, in prep.

2030s Precipitation Extremes



Diourbel, Senegal probabilistic projections to 2050s factor in mean changes and internal variability

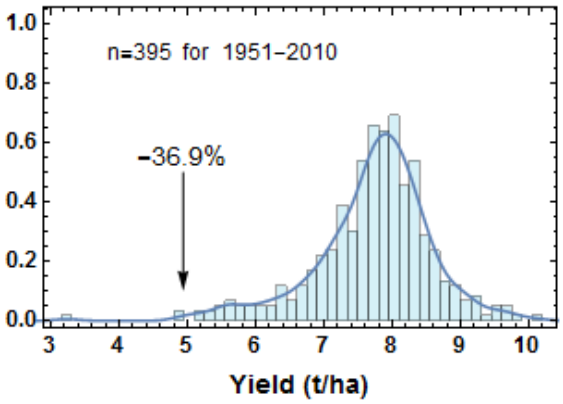
Initial investigations show that extreme events embedded in mean climate change will have strong impact on potential outcomes and adaptation strategies

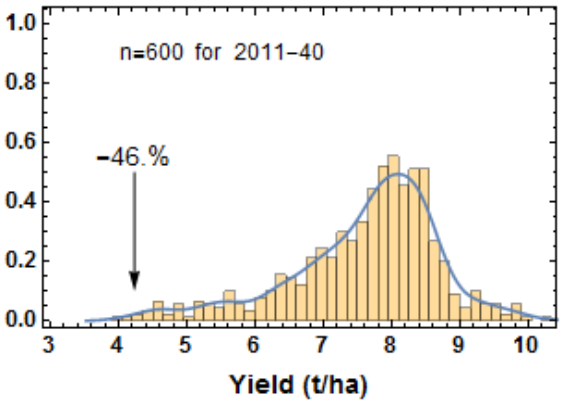
(work done in collaboration with Arthur Greene and James Chryssanthacopoulos)

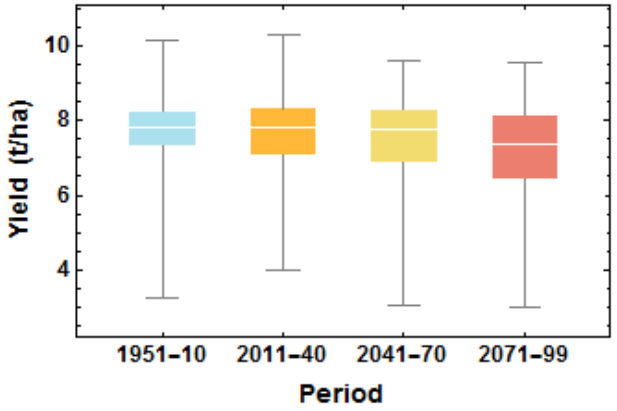
Food System Shocks and Resilience

➢ UK-US Taskforce on Extreme Weather and Global Food System Resilience (from Joshua Elliott et al.)

- US maize, 1-in-200 year event ~25% worse in near-term even as mean is stable or even increasing – tendency toward more extremes







➢ Lloyd's of London Report – Food System Shock (from Molly Jahn et al.)

- Generated a scenario with multiple, simultaneous bread basket impacts
- Worldwide reduction of rice, maize, and soybean production (-7%, -10%, -11%)
- Socioeconomic implications: huge increase in rice prices, large losses in stock markets, riots, terrorism, and other outcomes
- Calls for better models of response to food system shocks

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Other projects of note:

- **AgMIP Global Gridded Crop Model Intercomparison (GGCMI) –**
Comparing ~15 crop models driven by 9 gridded climate datasets from 1980-2009. Focus on understanding response to climate variability and extremes.

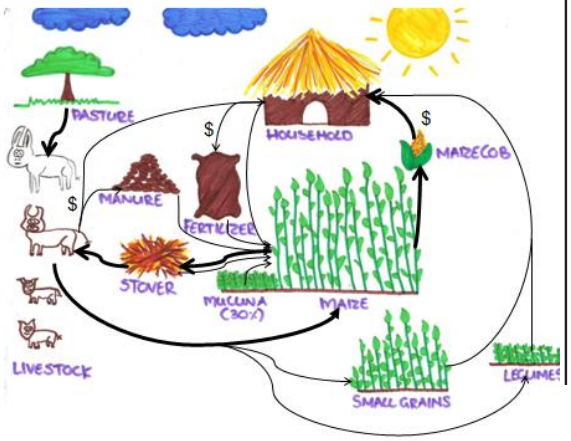
- **AgMIP Pests and Diseases –**
Launched in February, 2015; examining specific species outbreaks as well as generic approach with 8 types of plant damage

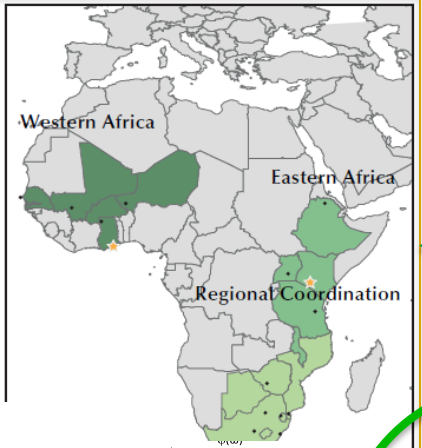
- **MODEXTREME –**
Comparing against observations of extreme events to improve models (particularly CropSyst and WOFOST for Europe)

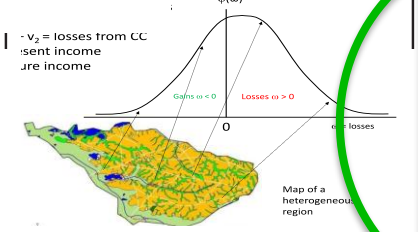
AgMIP Coordinated Regional and Global Assessment

Coordinated Global and Regional Multi-Model Assessments

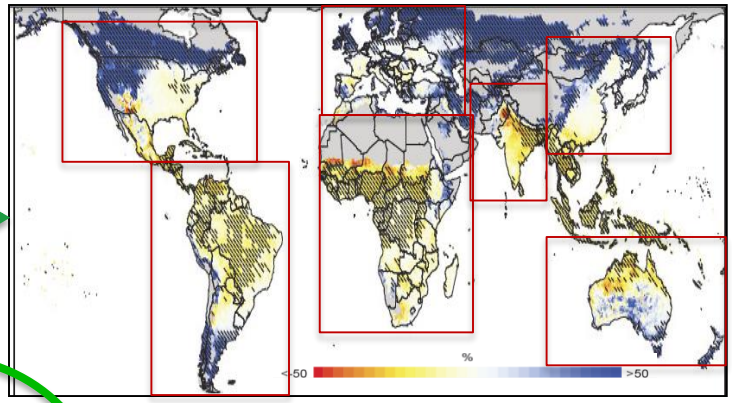
AgMIP The Agricultural Model Intercomparison and Improvement Project





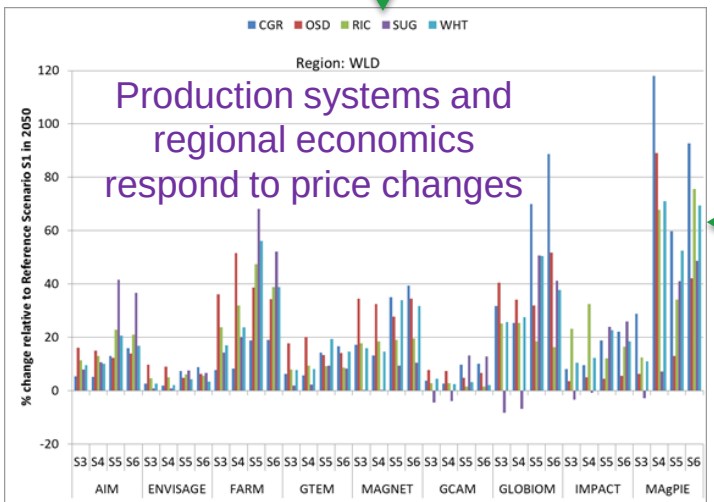


RRTs – Farming systems biophysical and socioeconomic models



GGCMI -- High-resolution gridded crop modeling for gap-filling and aggregation in each region

RCPs
SSPs
RAPs



Production systems and regional economics respond to price changes

Global Economics – Model analysis of world and regional prices

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Summary

- AgMIP and related projects are conducting several activities to understand and improve crop model response to extreme events
- This involves crop model studies as well as the generation of climate datasets and scenarios more capable of capturing extremes
- Models are typically less responsive to extreme events than we observe, and miss several forms of extreme events
- Models also can capture interactive effects between climate change and climate extremes.
- Additional work is needed to understand response of markets and economic systems to food shocks.
- AgMIP is planning a Coordinated Global and Regional Assessment of Climate Change Impacts on Agricultural Production and Food Security with an aim to inform the IPCC Sixth Assessment Report.

Thanks!

Contact me: **alexander.c.ruane@nasa.gov**

Please visit www.agmip.org for more information