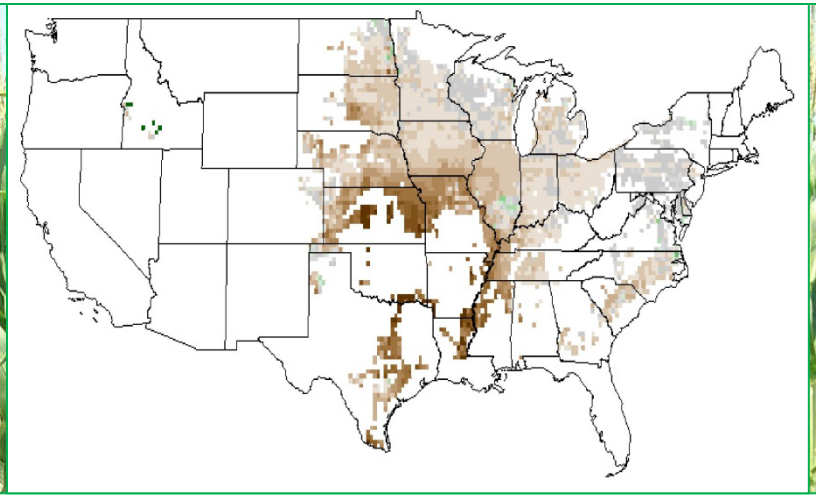
The Agricultural Productivity Indicator and Analysis System (APIAS)



PI: Alex Ruane, Joshua Elliott, Michael Glotter, and Jonathan Winter

NASA INCA PI Meeting – April 8th, 2014

Goddard Institute for Space Studies
New York, N.Y.

Dartmouth

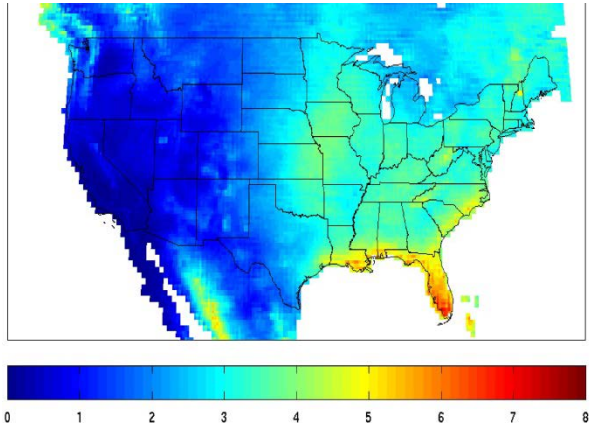
THE UNIVERSITY OF CHICAGO

COLUMBIA UNIVERSITY

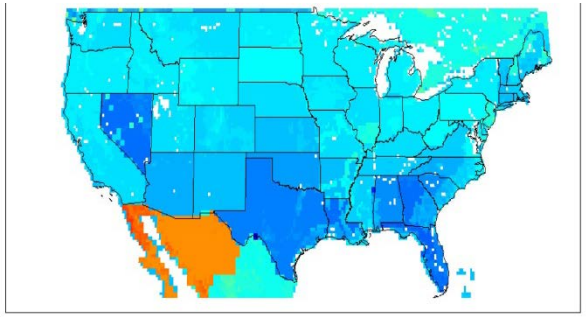
Overview

- Aims of APIAS
- Configuration of Maize Model
- Preliminary Results from Near-term Projections
- Example Analyses from Southern Iowa
- Next Steps

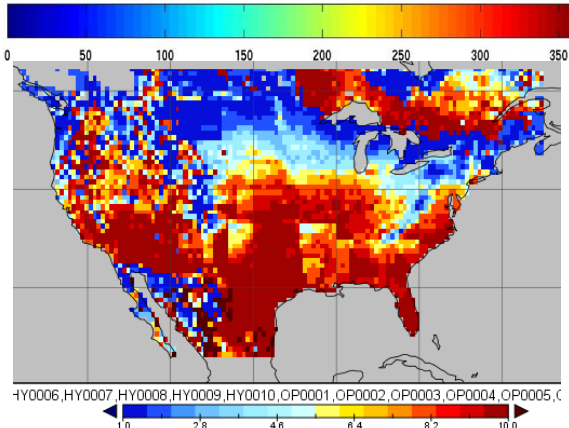
Agricultural Modeling of Climate Change Impacts: pDSSAT crop model



Climate:
Precipitation,
Tmax, Tmin,
Solar radiation,
Wind Speed
CO_2 concentrations

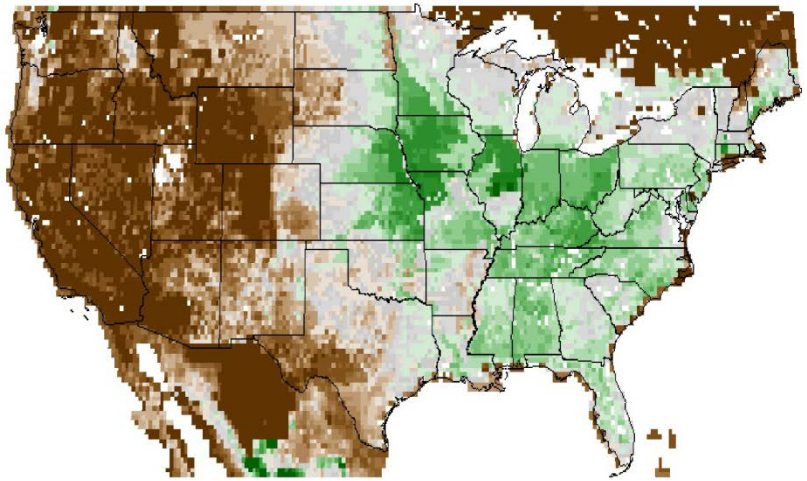


Geodata:
Planting Dates,
soils,
planted areas

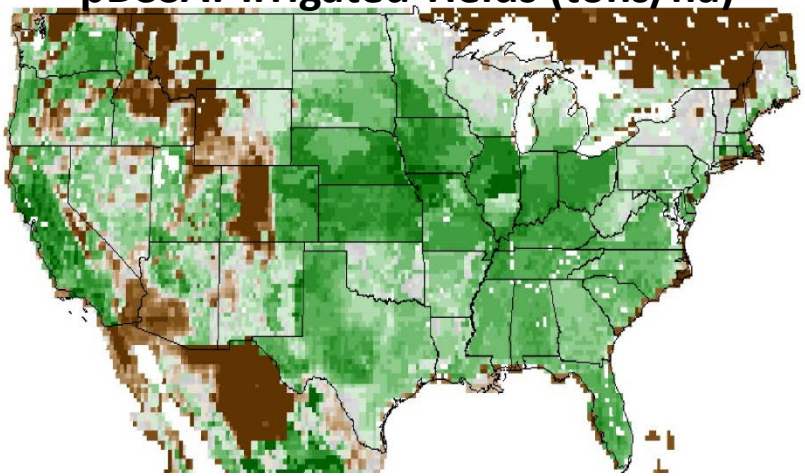


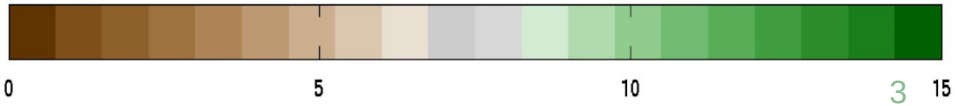
Management:
Cultivar types,
fertilizers,
irrigation

pDSSAT Rainfed Yields (tons/ha)

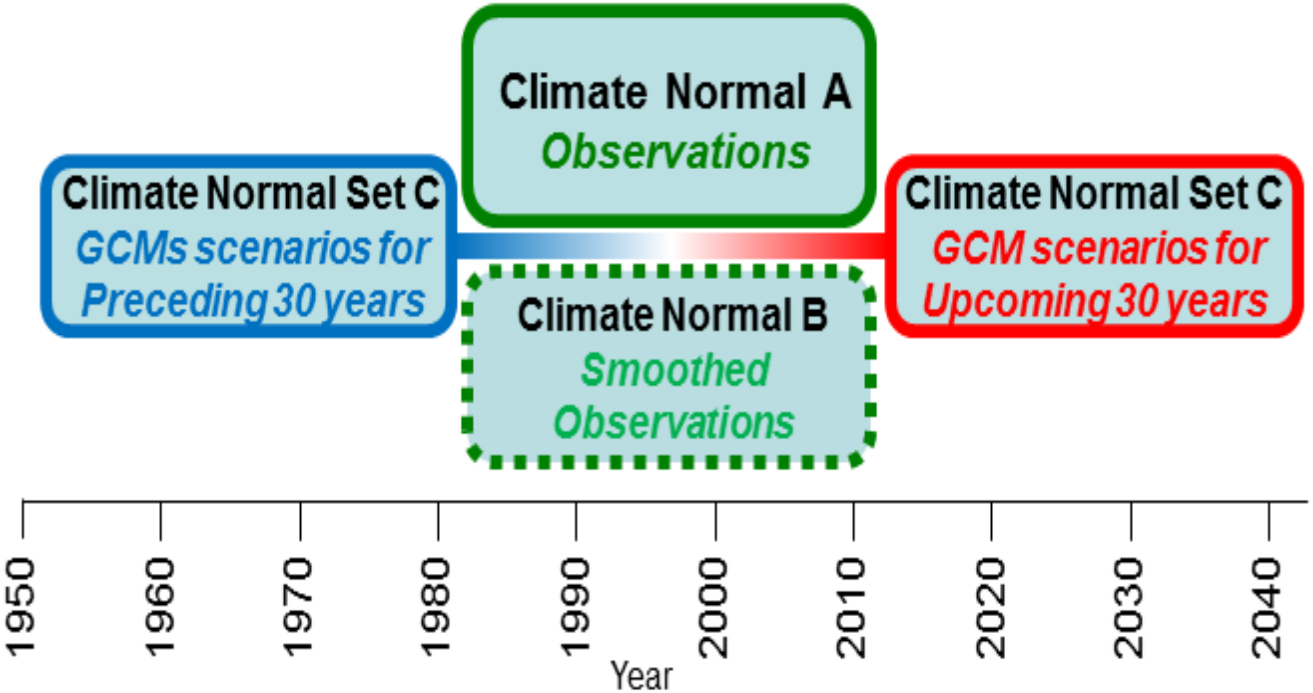


pDSSAT Irrigated Yields (tons/ha)





Climate data and scenarios: Drive pDSSAT with three climate datasets

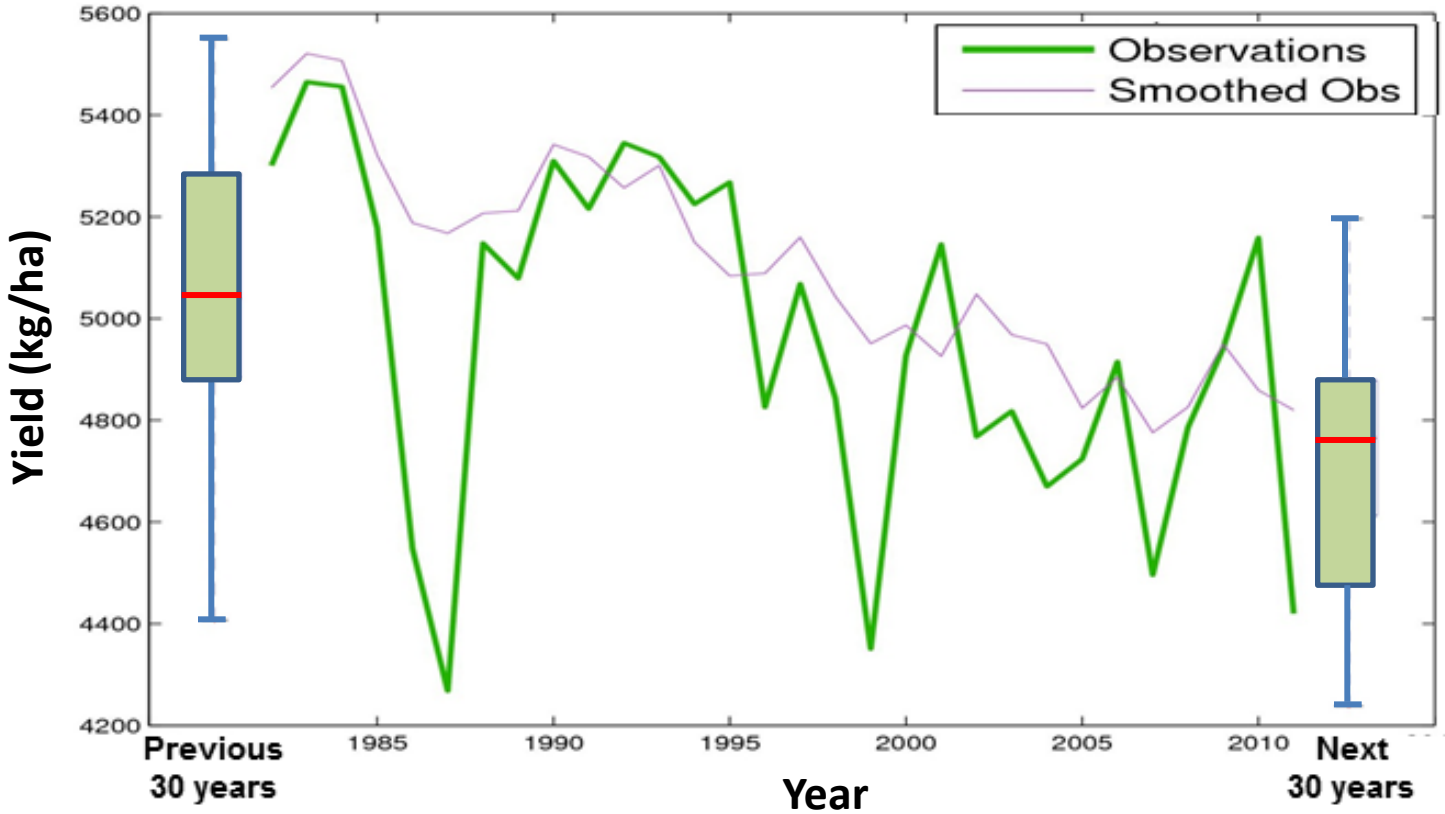


A) Observations of last 30 years: based upon AgMERRA (value-added version of MERRA-L and NASA/GEWEX SRB and other geodatasets)

B) Smoothed observations of last 30 years:
30-day smoothing and rainfall adjustment to gauge sub-seasonal climate extremes

C) Scenarios for preceding and upcoming 30 years: based upon CMIP5 projections

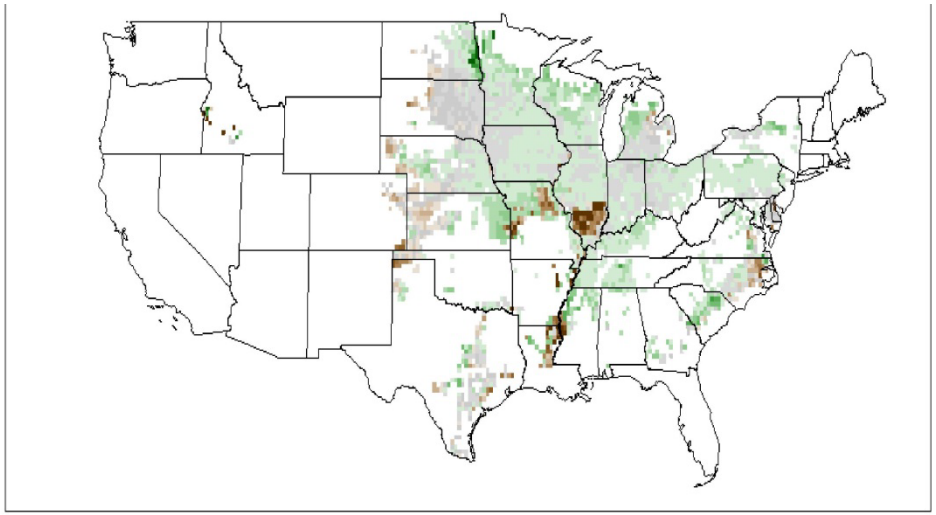
Hypothetical example of Agricultural Indicators Results (single county)



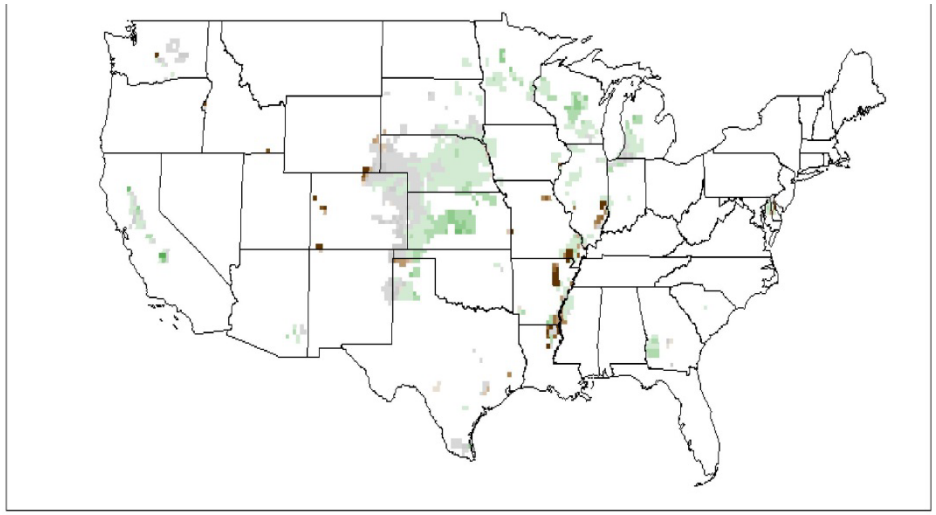
- Analysis may be performed at many spatial scales (e.g., county, state, region) and may differ by crop and management type (e.g., irrigated and rainfed systems).
- Future work will identify:
  - Areas breaking from expected trend
  - Historical events profoundly affected by sub-seasonal climate extremes
  - Farming systems that may be on the verge of threshold shifts in productivity

Investigation of a Smoothed-Climate Historical Scenario

Smoothed-Baseline
Rainfed Maize Yield Change



Smoothed-Baseline
Irrigated Maize Yield Change

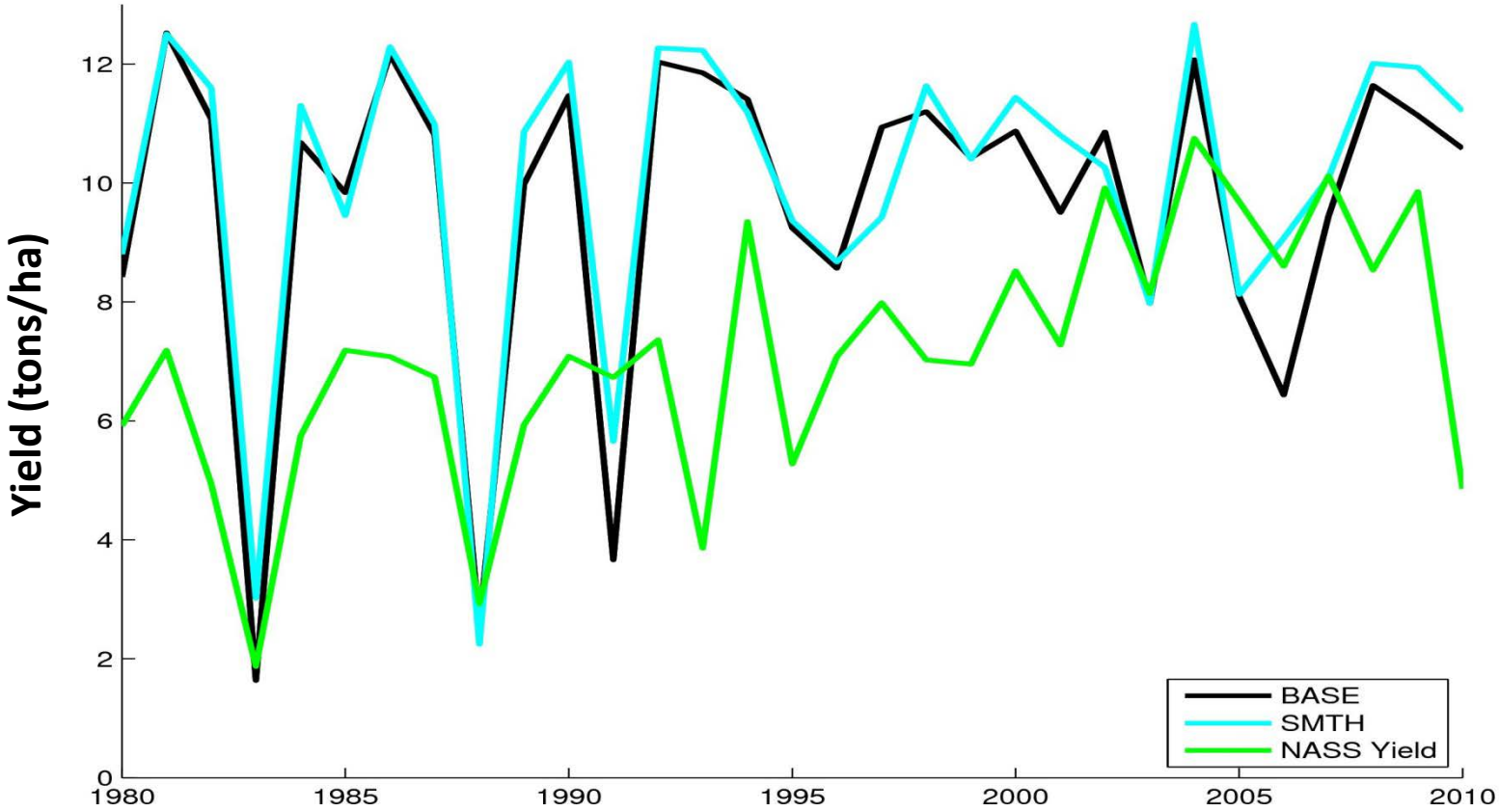


Compared AgMERRA-based historical dataset (based on MERRA, NASA/GEWEX SRB) against a smoothed version featuring:

- 30-day smoothing for wind speed, temperature, solar radiation
- each month had #rainy days smoothed halfway toward climatology
- rainfall amounts for each day set to constant within any given month

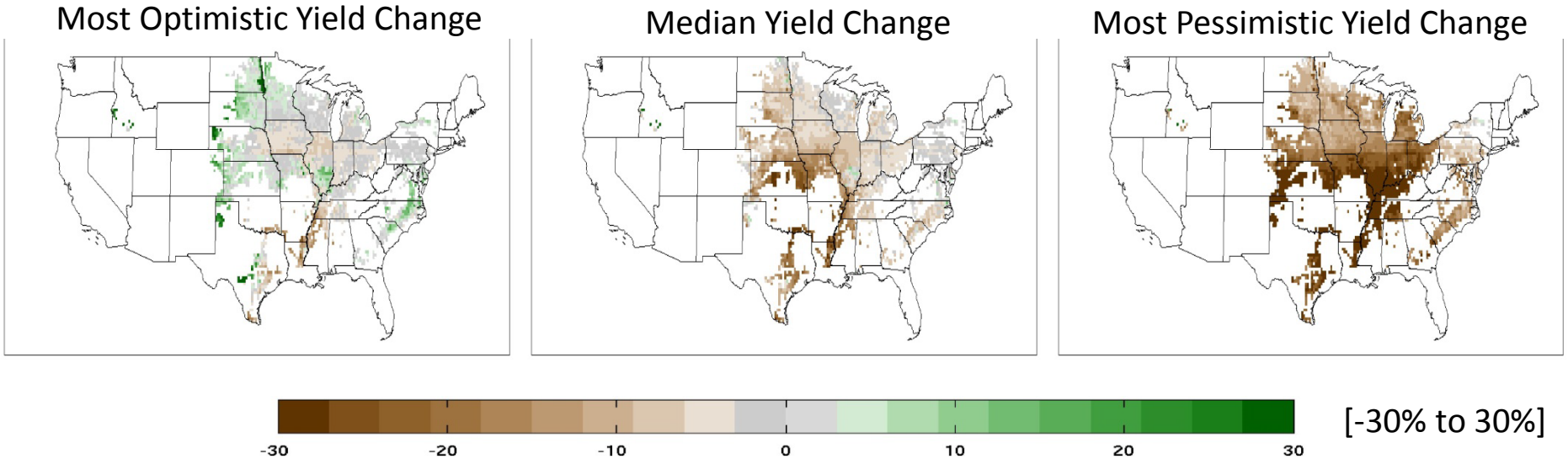
Smoothed yields are generally higher as extremes are more often detrimental

Southern Iowa Rainfed Maize Yields



- Smoothed climate reduces damages in 1984 and 1991, but not 1988
- Note: 1993 flood would not be expected in crop model
- Yield is from harvested (not planted) areas
- Yield trends are increasing overall (not just climate influences)

Rainfed Impacts from 5 Near-term (2020s) GCMs



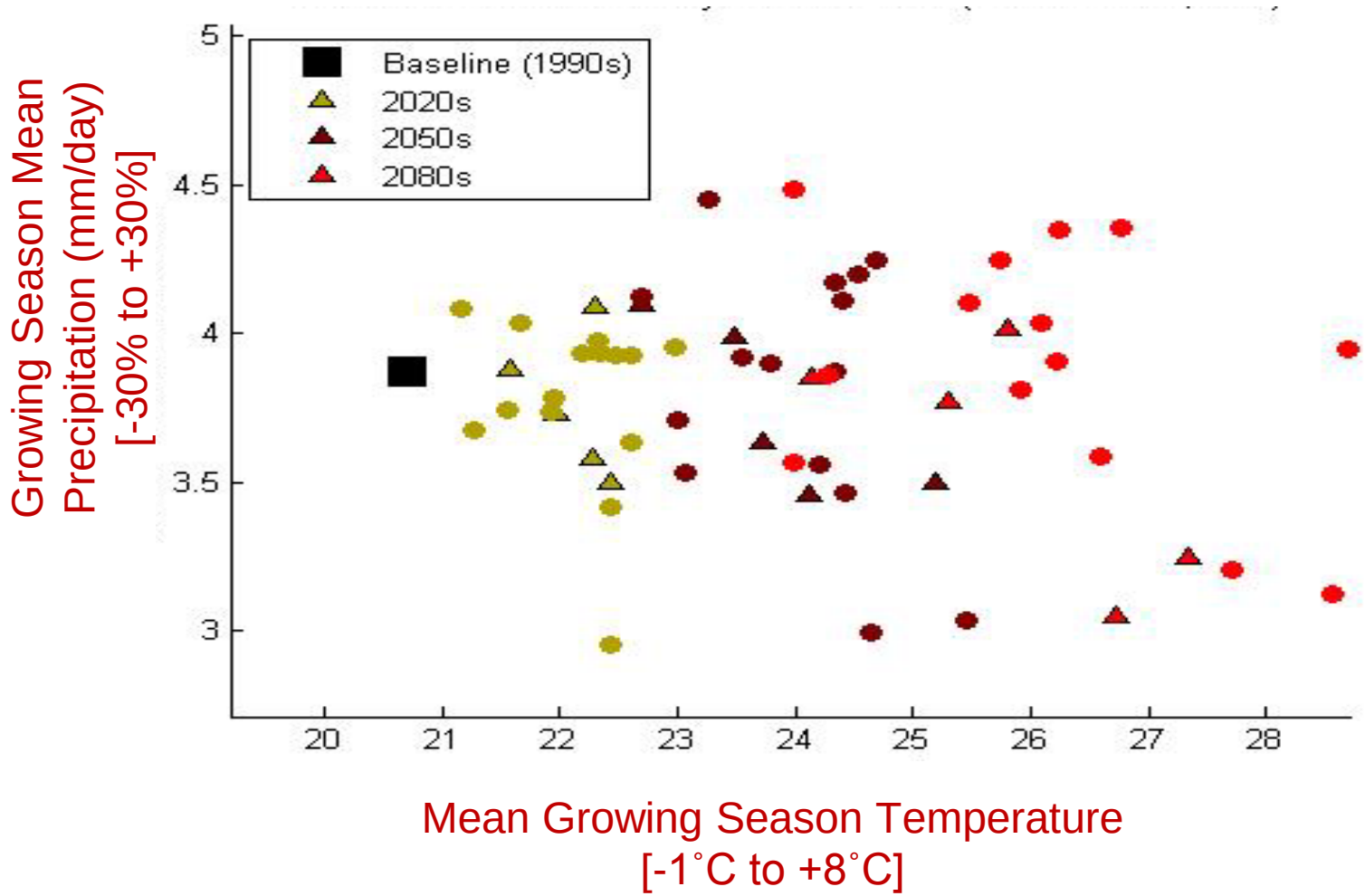
Climate change signal is obscured by noise within near-term climate scenarios

Median maize yields decline, but projections from some GCMs produce increases

Impact of changes in sub-seasonal extremes is small compared to mean changes

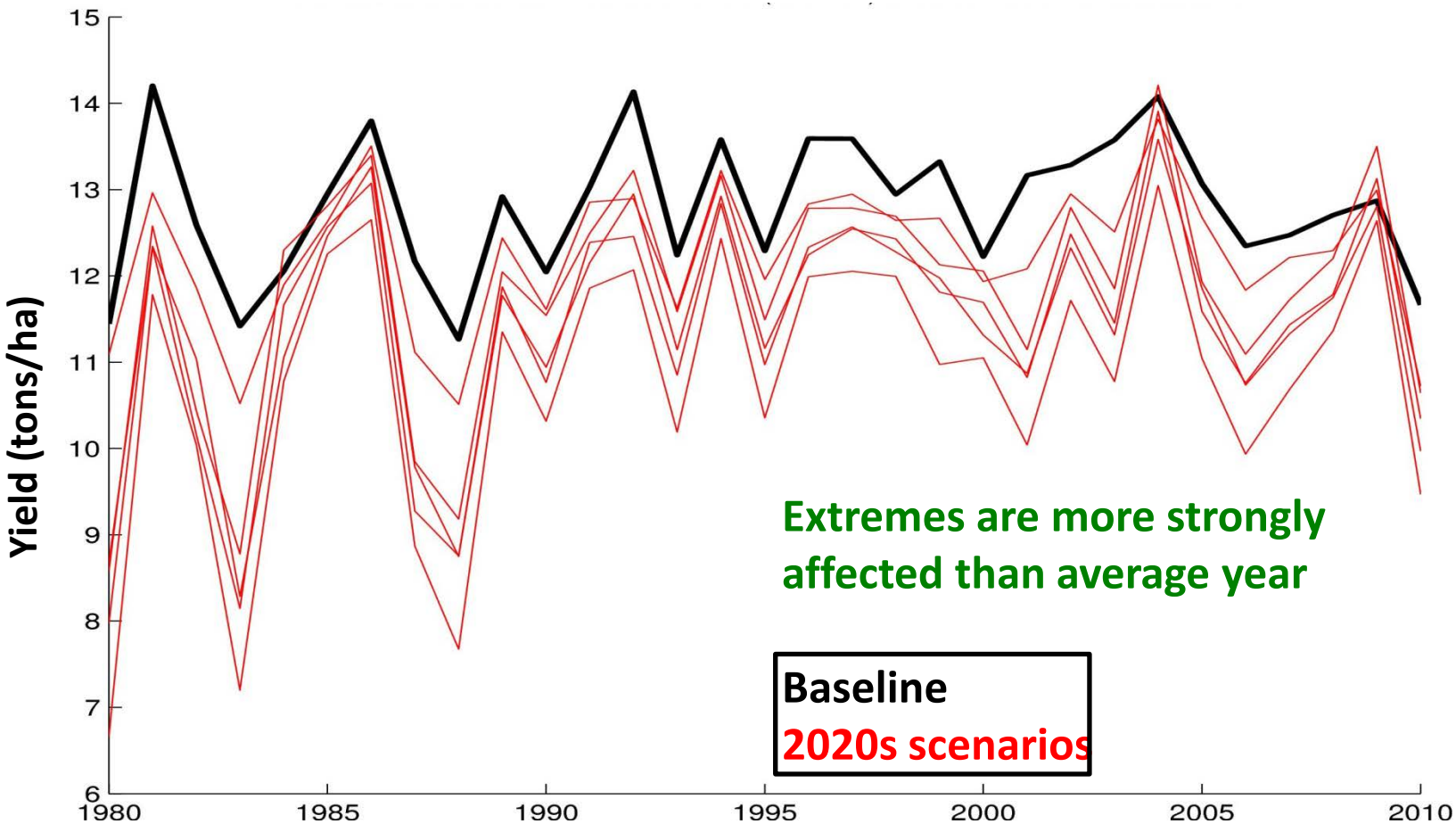
Uncertainty in Projections of 20 CMIP5 GCMs

(RCP8.5 projections shown for Southern Iowa)

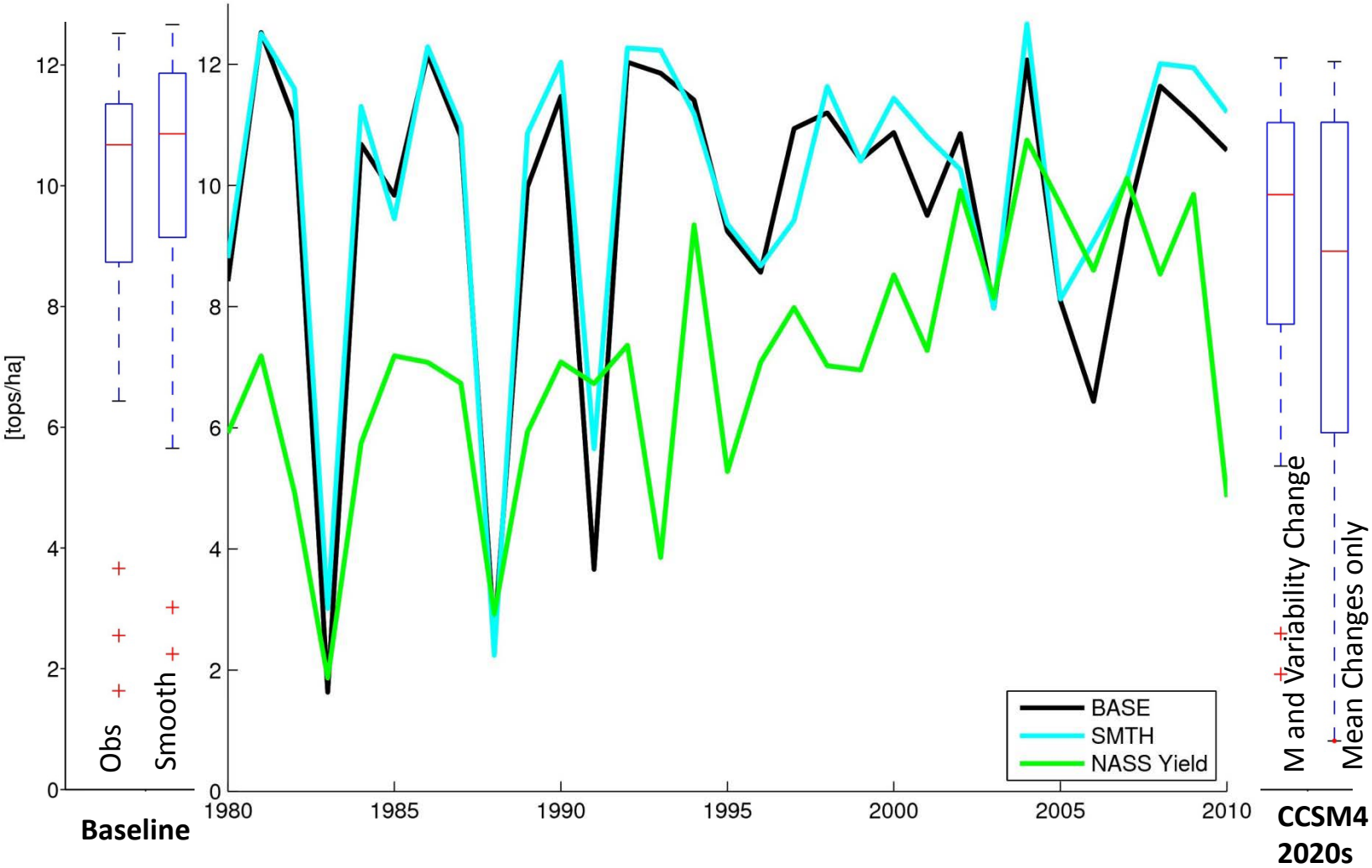


Following Ruane et al., 2014 (Global Change Biology)

Differential Impact of Climate Changes



Identifying Climate Pressures



Detrimental climate trends obscured by variability and agricultural development

We are identifying fingerprints attributable to specific climate pressures

Next Steps

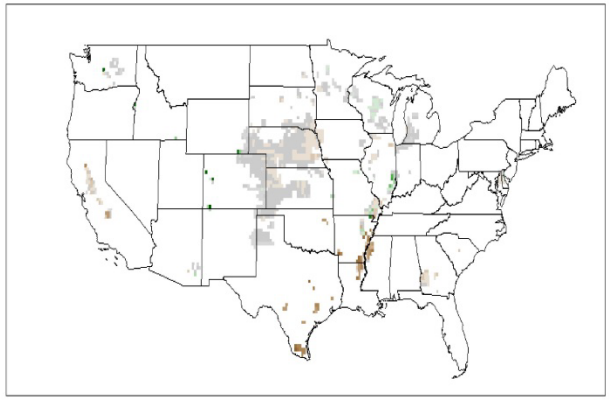
Identifying:
- regions where yields deviate from projected trends
- thresholds that cause more dramatic yield changes
- how climate extremes can have fortuitous and detrimental impacts on crop yields
- how shorter growing seasons interact with seasonal cycles in precipitation and temperature extremes
- how Penman-Monteith and Priestley-Taylor evapotranspiration parameterizations capture yield changes under extreme conditions

Designing:
- a suite of analyses and tools that will be available at any given latitude/longitude/county

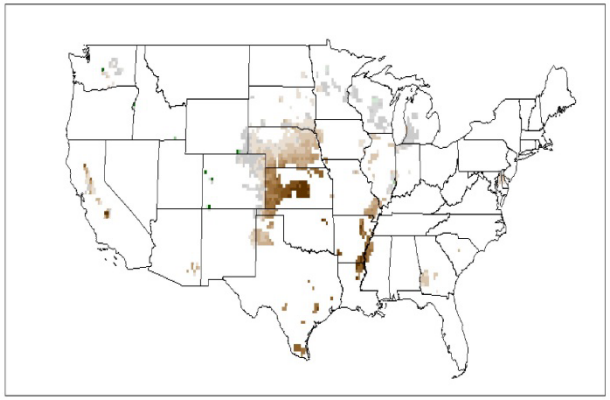
Expanding:
- additional crops (wheat, soybean), climate scenarios (more GCMs), crop models (pAPSIM)

Extra Slides

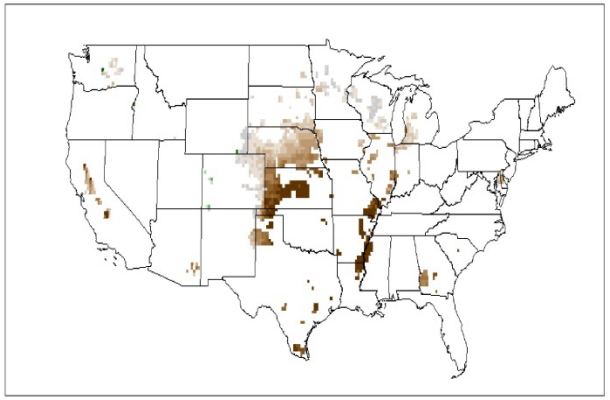
Mean IRR Maize Production Difference maxFscenarios-BASE with evapoF (%)

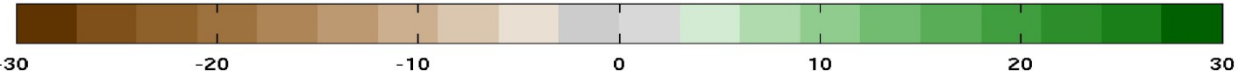


Mean IRR Maize Production Difference medianFscenarios-BASE with evapoF (%)

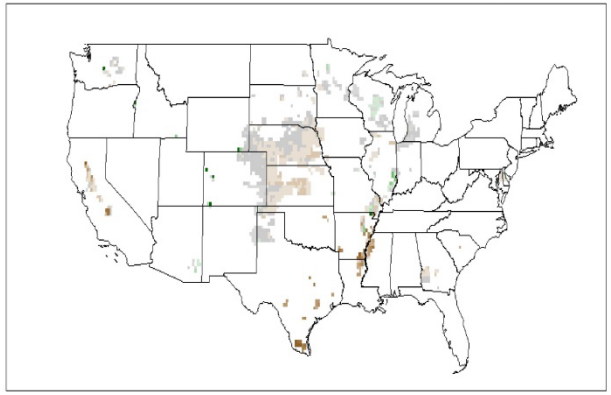


Mean IRR Maize Production Difference minFscenarios-BASE with evapoF (%)

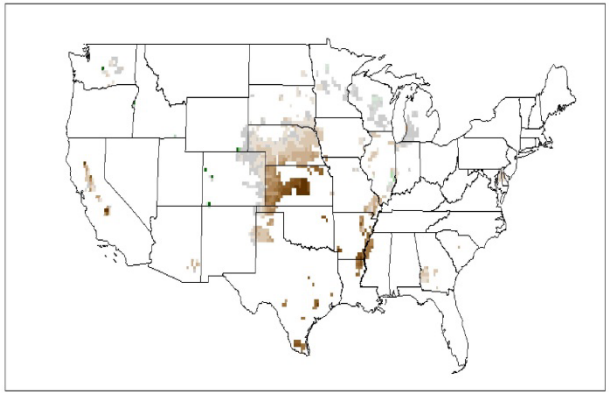




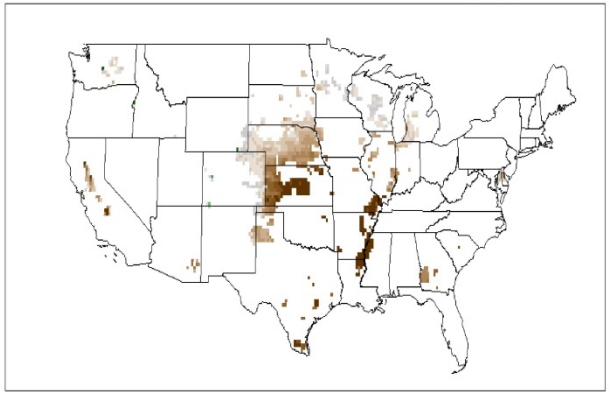
Mean IRR Maize Production Difference maxAscenarios-BASE with evapoF (%)

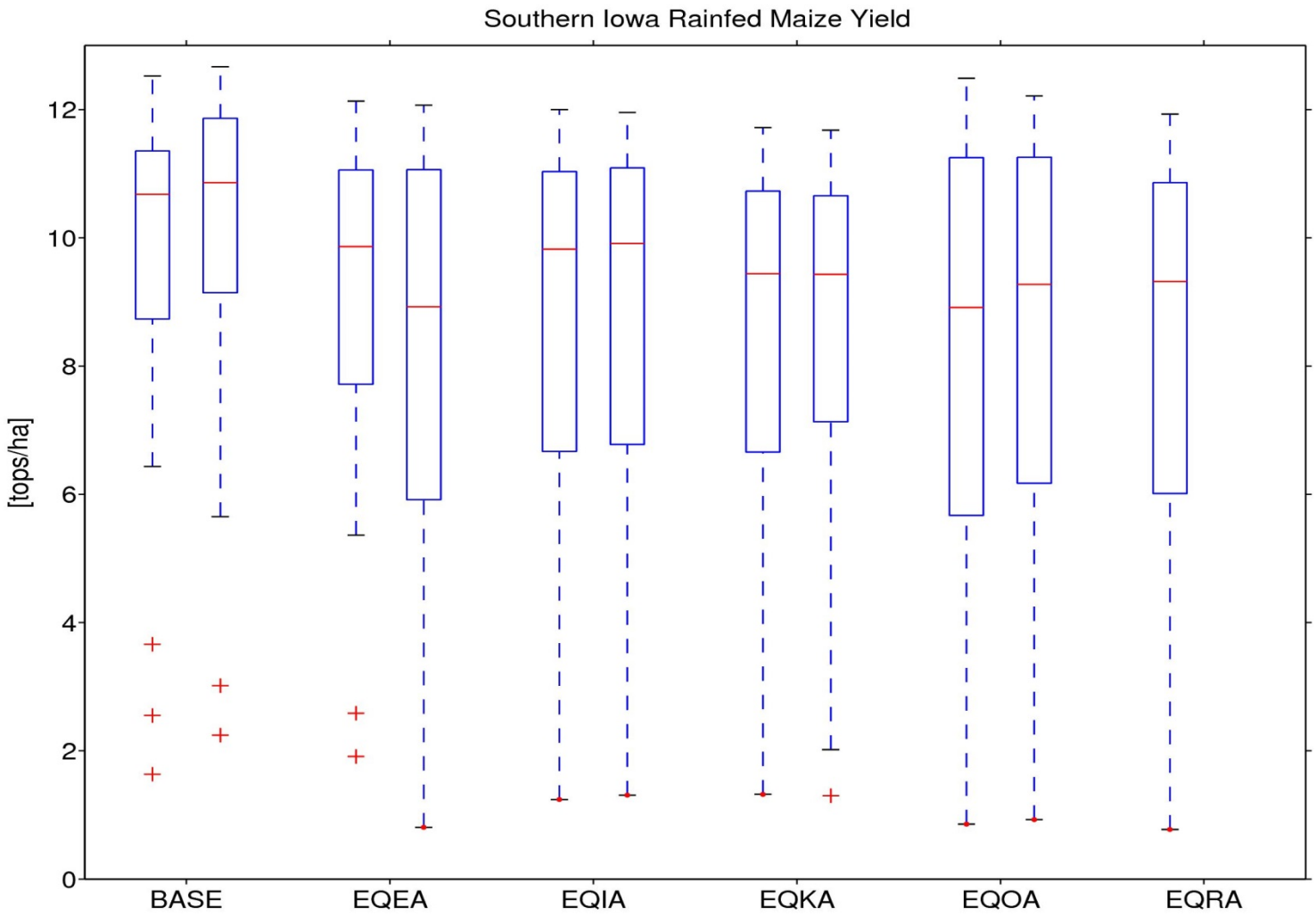


Mean IRR Maize Production Difference medianAscenarios-BASE with evapoF (%)



Mean IRR Maize Production Difference minAscenarios-BASE with evapoF (%)




Southern Iowa Rainfed Maize Yield
[tops/ha]
0
2
4
6
8
10
12
BASE
EQEA
EQIA
EQKA
EQOA
EQRA