Comparison of downscaling techniques for stakeholder-driven research in the urban Northeast U.S

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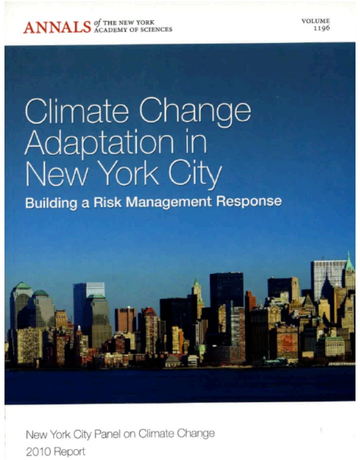
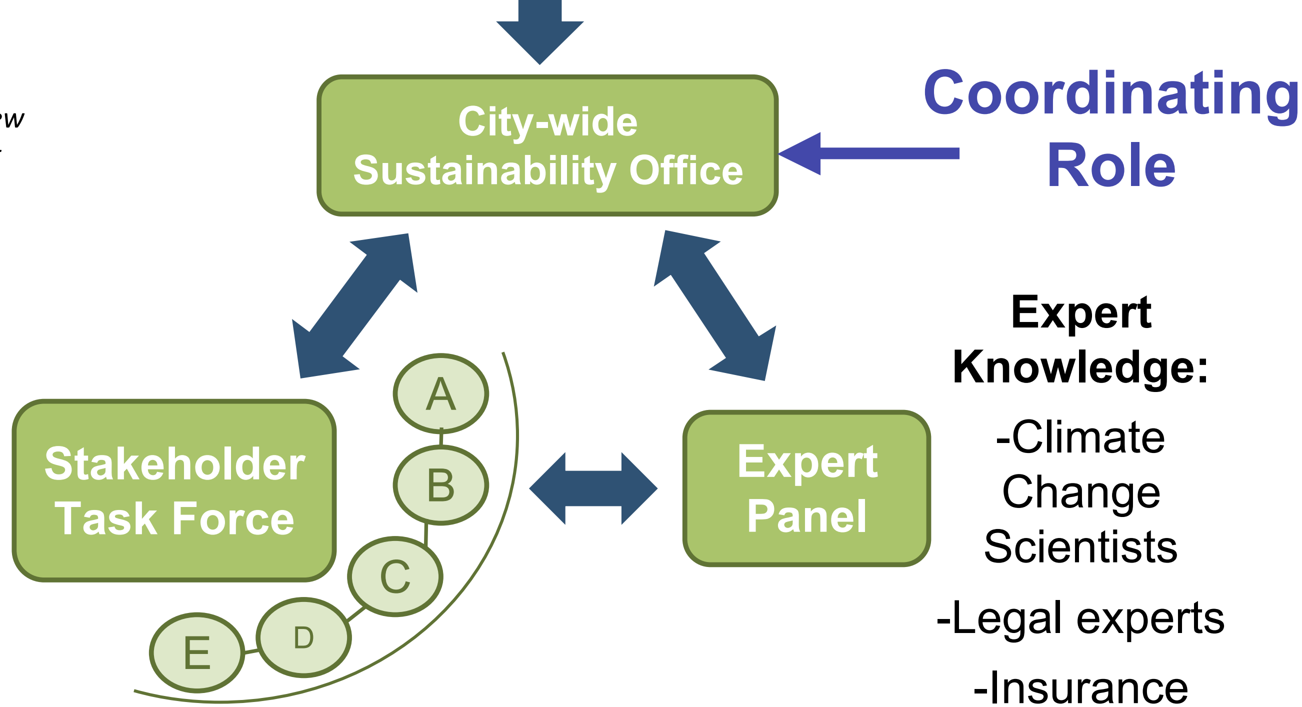
Outline

- **Stakeholder context and project examples in the Northeast U.S.**
- **Preliminary analysis of some NARCCAP results in the Northeast U.S., with comparison to other downscaling methods**
- **Application of NARCCAP intra-annual variability to crop models in the Southeast U.S.**
- **Overview of Agricultural Model Intercomparison and Improvement Project (AgMIP)**

NYC Stakeholder Engagement Process



NPCC - Climate Change Adaptation in New York City: Building a Risk Management Response



Stakeholders include:

- City Agencies
- Regional Authorities
- Private Stakeholders

Expert Knowledge:

-Climate Change Scientists

-Legal experts

-Insurance experts

Source: NPCC, 2010

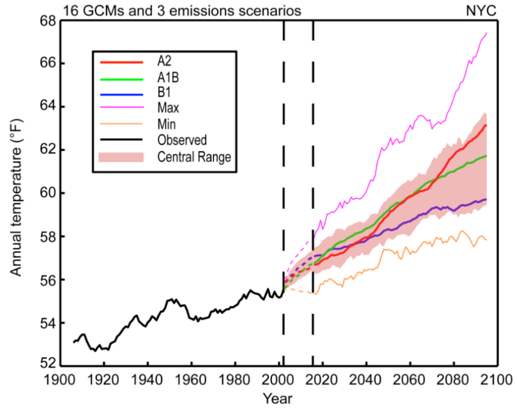
Climate Hazard Information

Process used to develop climate risk factors for New York City

Global climate scenarios
- SRES greenhouse gas emissions pathway
- GCM simulations

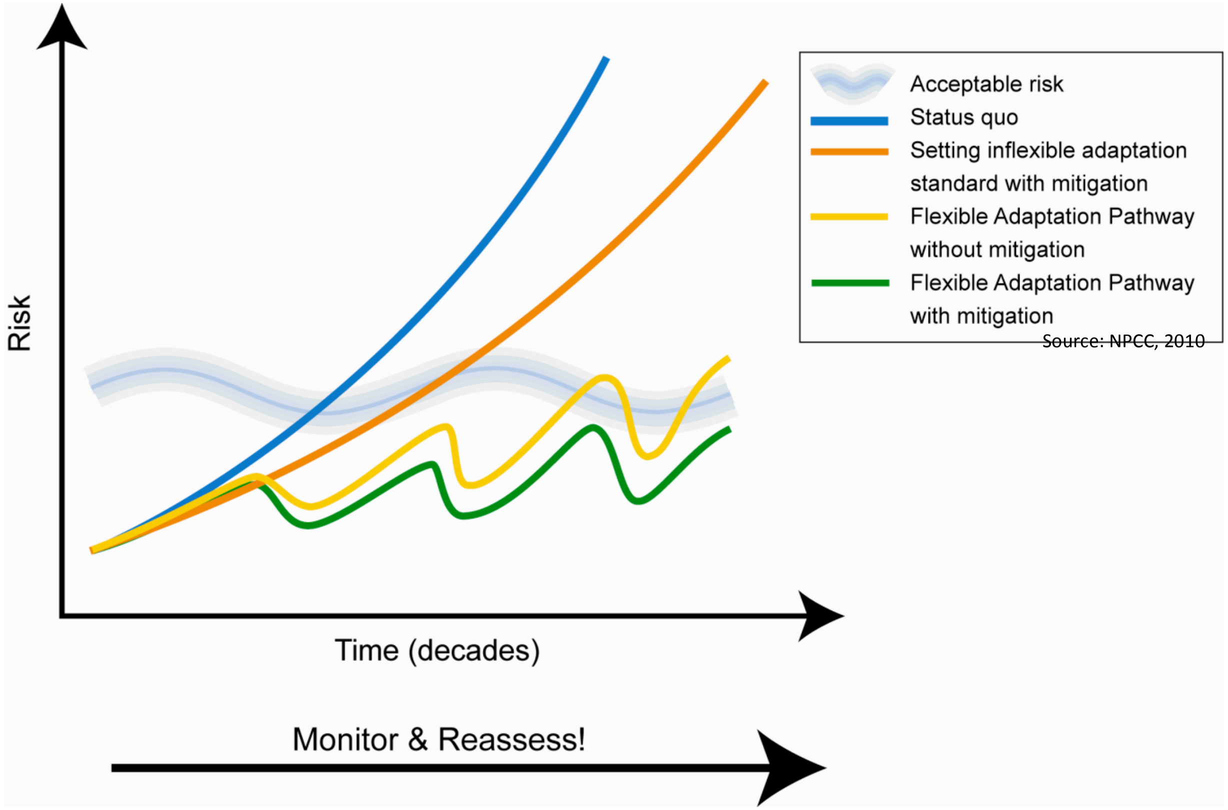
Local climate change information
- Observed data
- Quantitative GCM-based projections
- Qualitative GCM-based projections

Climate risk factors
- Generalized climate hazards of most consequence to NYC infrastucture used to determine critical infrastructure at-risk.

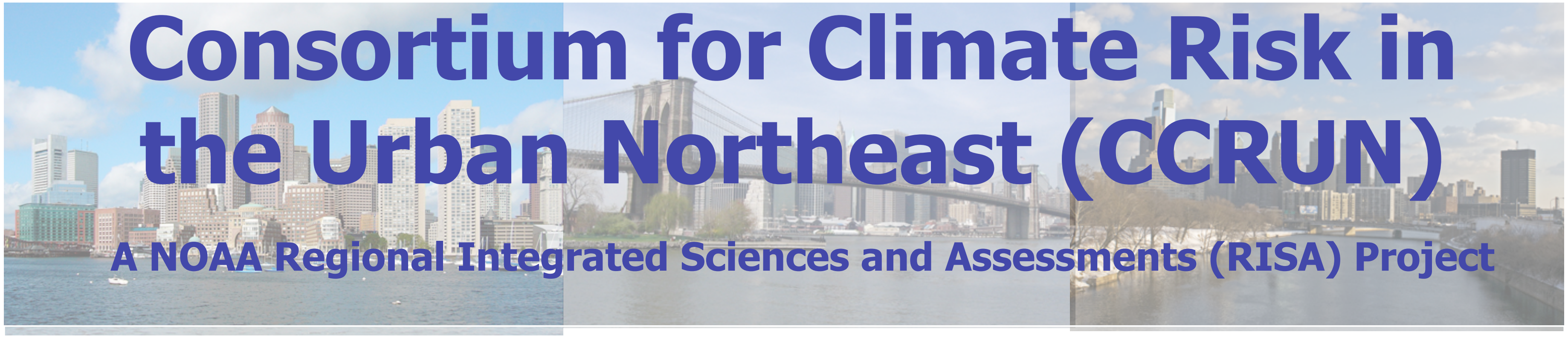


- **Projection Range, based on 16 GCMs and 3 SRES scenarios**
- **Time slice experiments based on single GCM gridbox, delta method approach**
- **Key thresholds**
  - **Number of days below 32 °F (transportation sector)**
  - **Number of days above 90 °F (energy and health sectors)**
  - **Number of intense precipitation events (e.g., .5 in./day; water sector)**
- **Qualitative projections**

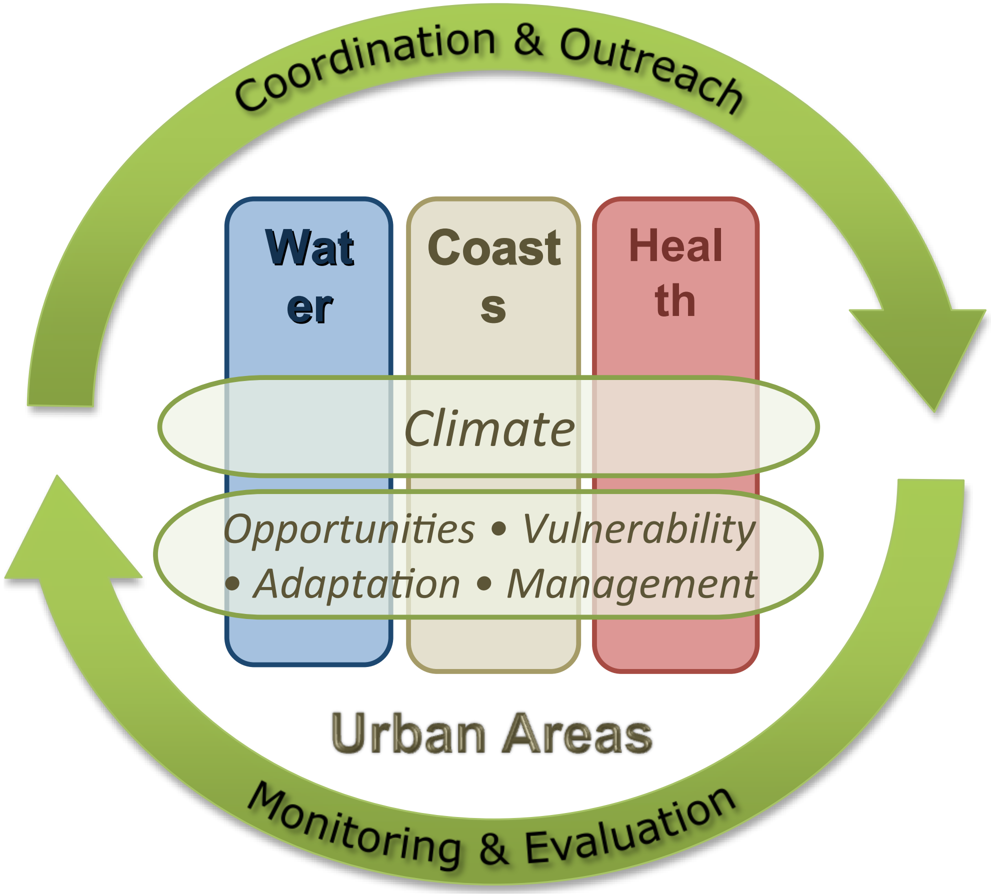
Flexible Adaptation Pathways



Key elements to achieve Flexible Adaptation Pathways are a guiding framework, stakeholder engagement, expert knowledge providers, recurring assessment process, Action Plans by decision-makers, and vertically/horizontally integrated projects with ongoing evaluation



Boston *New York* *Philadelphia*



Downscaling Products and Techniques

- **Single GCM gridbox approach**
  - **Delta method applied to station data (NYC Panel on Climate Change)**

- **Bias-Corrected and Spatial-Downscaled Projections http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/ (BCSD; Maurer, et al. 2007, based on Wood et al. 2002, 2004, and Maurer 2007)**
  - **Direct use of monthly time series for impact models**
  - **For daily projections at station level, we use delta method and random sampling**

- **RCM simulations from the North American Regional Climate Change Assessment Program archive (NARCCAP; Mearns et al. 2009, EOS)**
  - **Changes in frequency and duration of key extremes**
  - **Changes in (intra-annual) variability more generally**
  - **Delta method**

NARCCAP Simulations

- **RCMs were run at 50km resolution for three experiments:**
  - **NCEP Reanalysis-driven, December 1979-November 2000:**

    *How well do the RCMs simulate ‘observations’ over the NE, when driven by ‘perfect’ boundary conditions?**

  - **GCM hindcast-driven, December 1970-November 2000**

    How sensitive are the RCM results to ‘biases’ in the driving GCMs?**

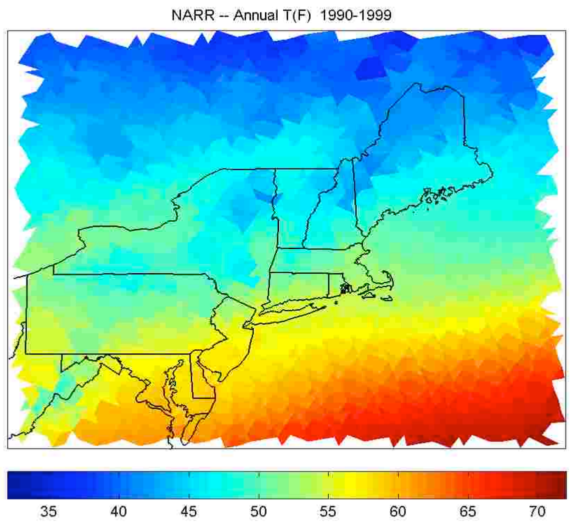
  - **GCM future-driven, December 2041-November 2070, A2 SRES Scenario**

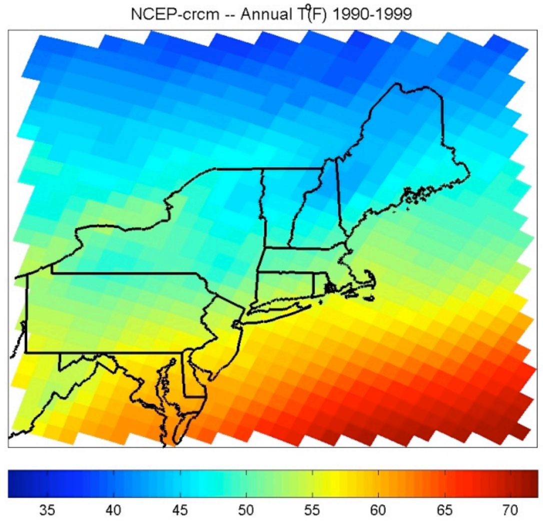
    *How does the forcing associated with greenhouse gases and other radiatively important agents manifest itself at more local scales?**

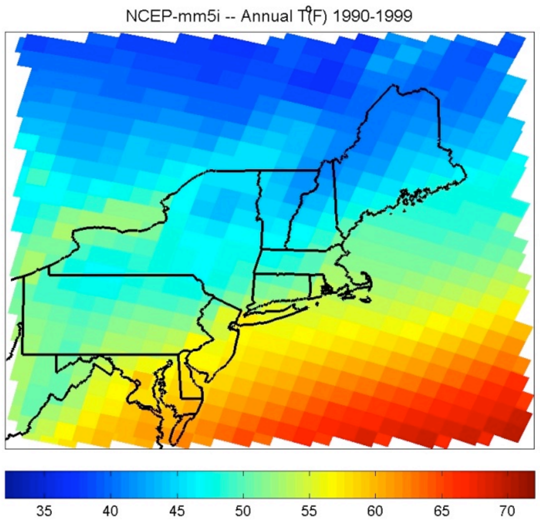
**Several caveats here…*

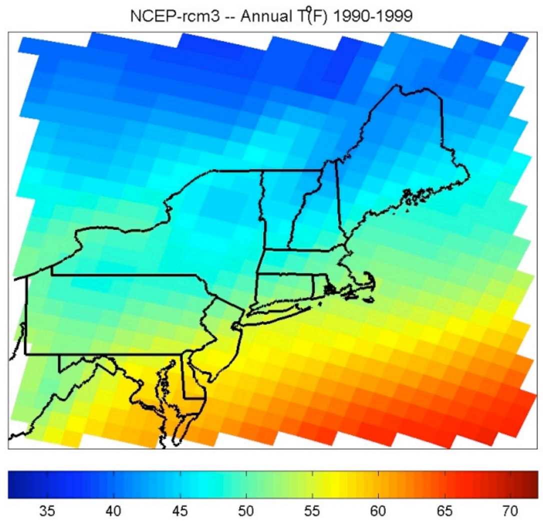
Annual Temperature (°F), 1990-1999

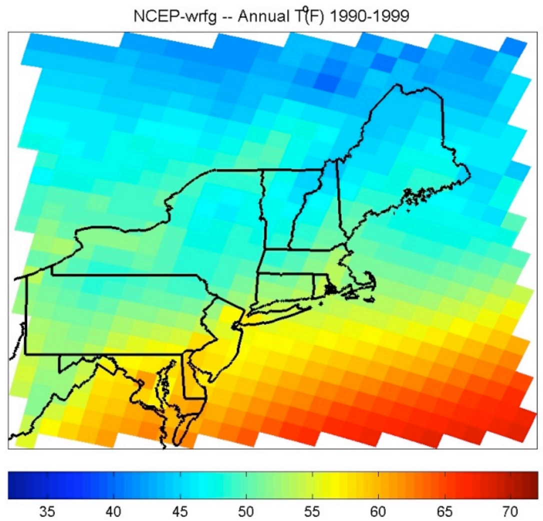
How well do the RCMs simulate 'observed' mean temperature over the NE, when driven by 'perfect' boundary conditions?





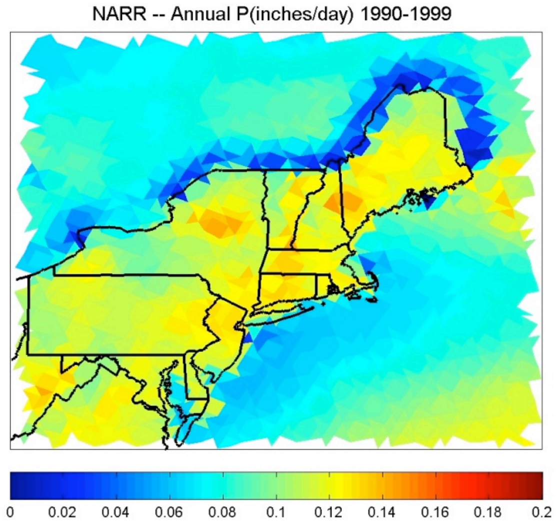


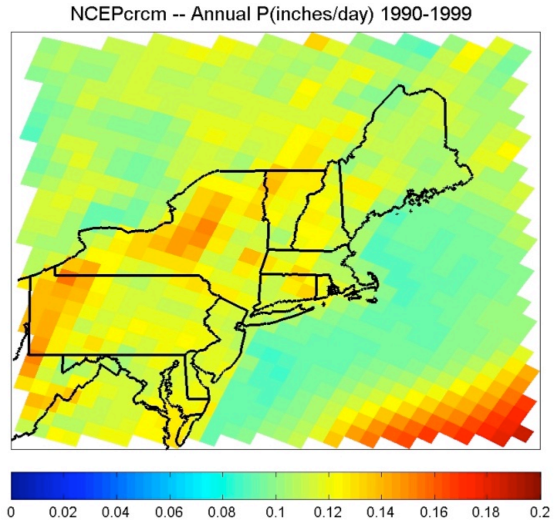


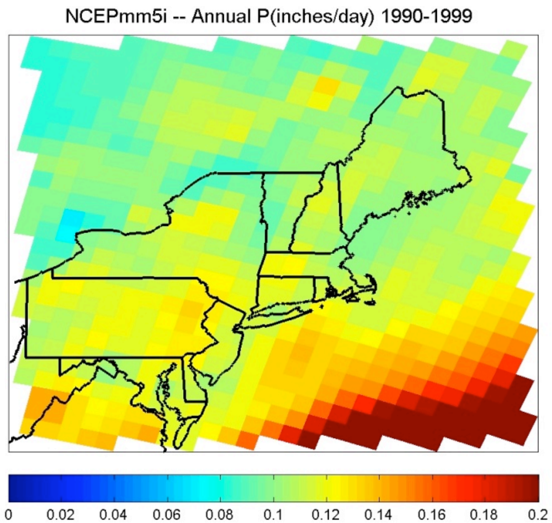


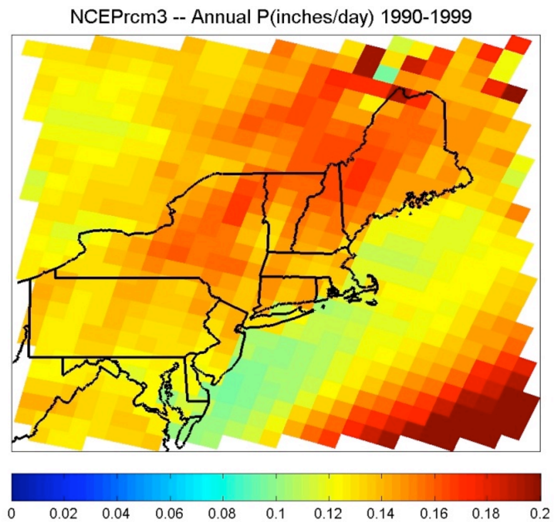
Annual Precipitation (in./day), 1990-1999

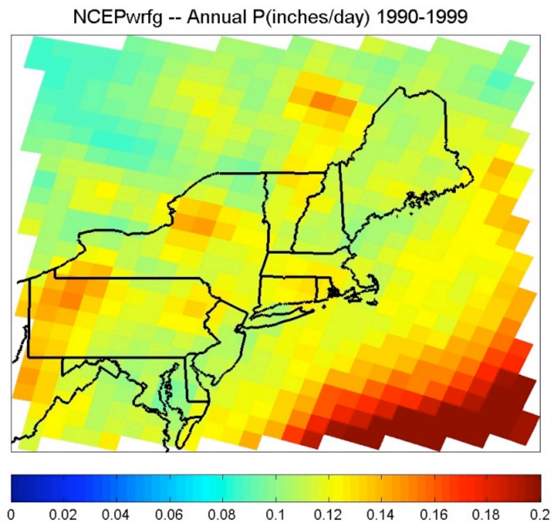
How well do the RCMs simulate 'observed' mean precipitation over the NE, when driven by 'perfect' boundary conditions?



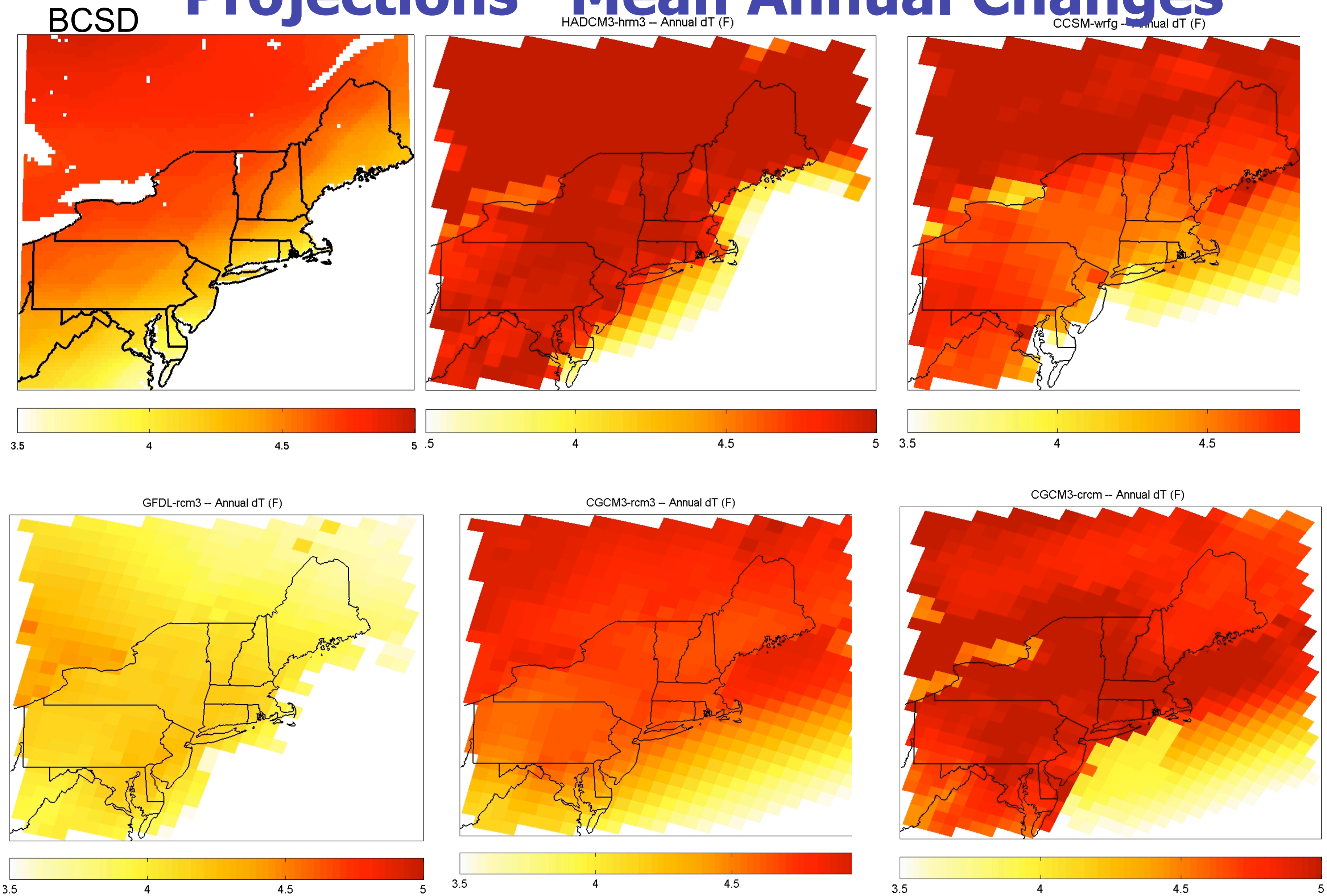






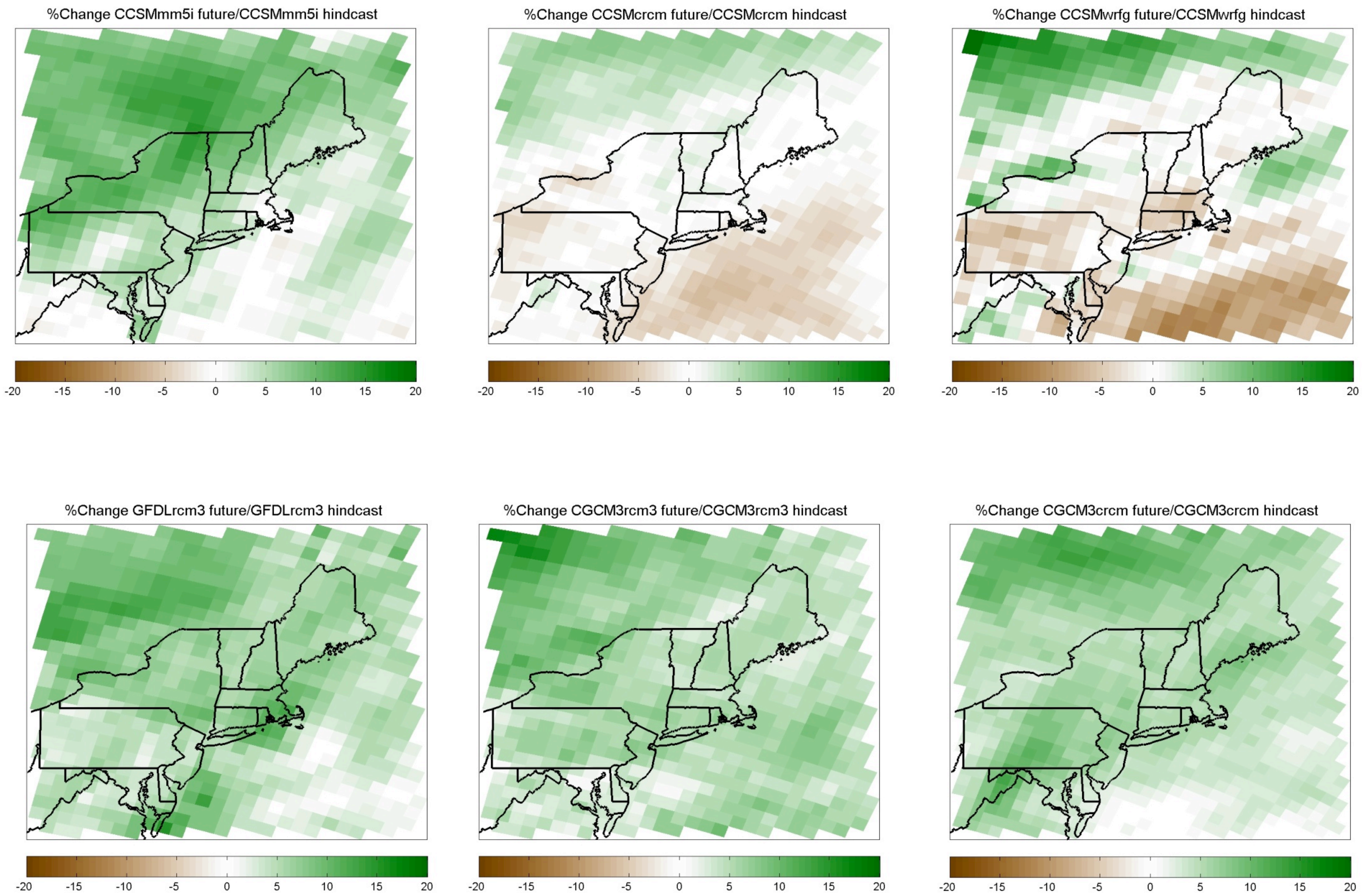


Projections--Mean Annual Changes



SRES A2 2050s minus 1980s annual temperature (°F)

Projections--Mean Annual Changes



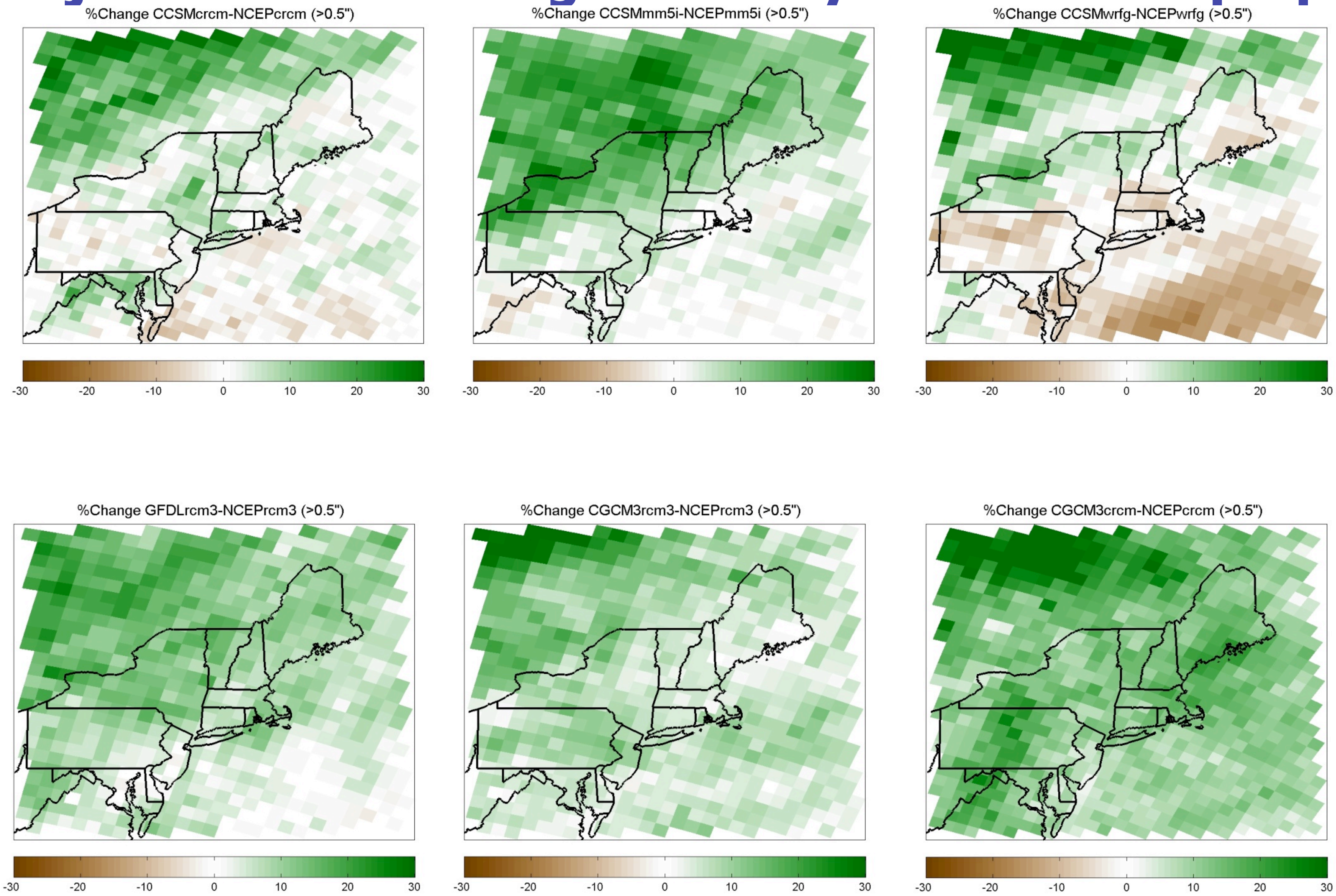
SRES A2 2050s divided by 1980s annual precipitation (%)

Projections--Mean Changes

NYC Gridbox (# of simulations)	Mean Annual Temperature Change (°F)	Mean Annual Precipitation Change (%)
GCM (16)	2.5 to 6.1 **(4.1)**	-9 to 10 (**5**)
BCSD (16)	2.9 to 5.7 (**4.2**)	-6 to 23 **(5)**
NARCCAP (4)	4.3 to 5.9 (**4.6**)	0 to 14 (**5**)

SRES A2-driven 2050s divided by 1980s GCM hindcast-driven

Projections--% Change in # days with >.5 in prcp

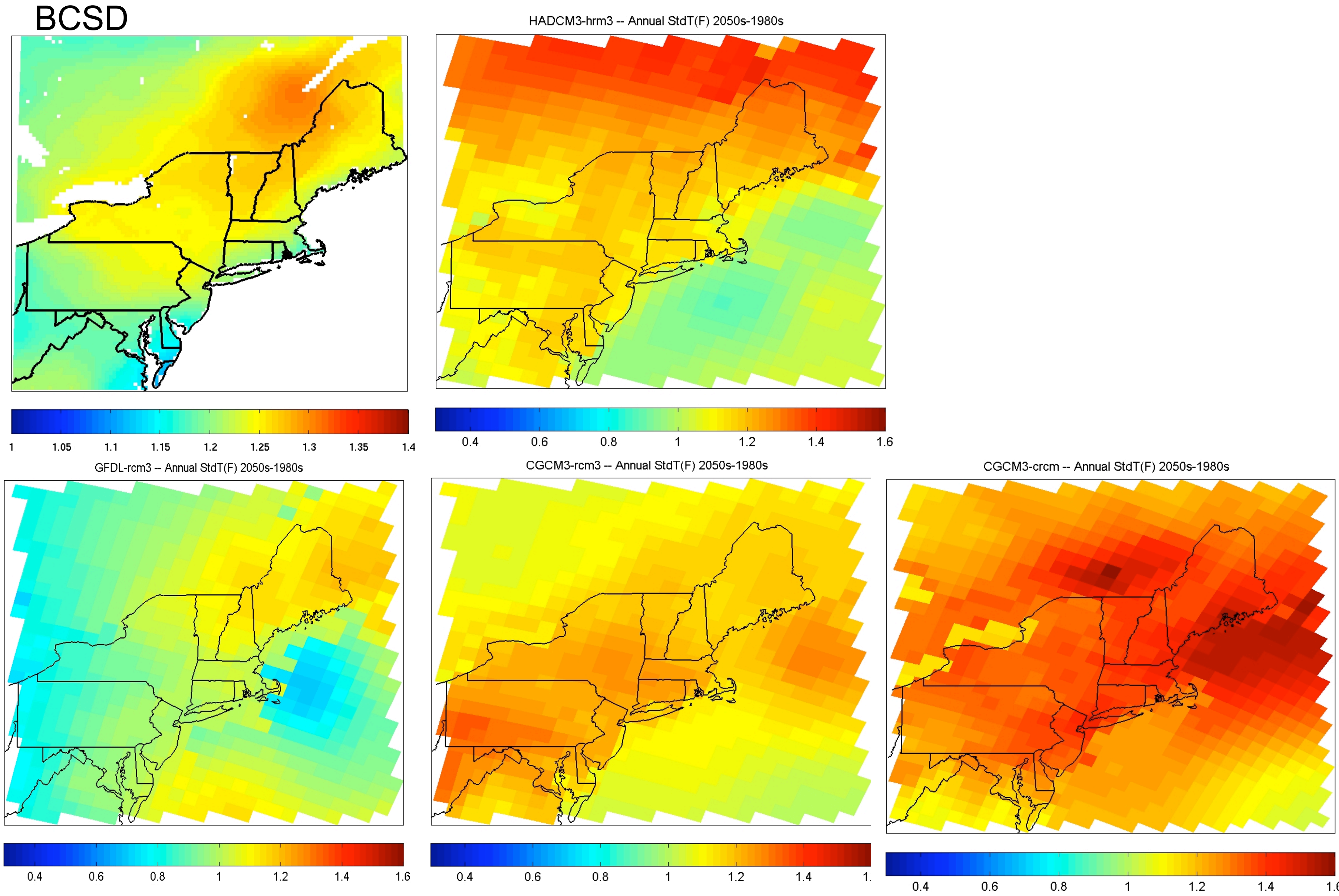


SRES A2-driven 2050s divided by 1980s GCM hindcast-driven

Projections--Extreme Temperatures

New York City	Number of days per year over 90 °F	Number of days per year at or below 32 °F
GCM (Delta Method)	14: 28 to 58	72: 31 to 53
BCSD (Hybrid Technique)	14: 24 to 51	72: 45 to 64
NARCCAP (Actual Values)	0 to 3:0 to15	52 to 88:28 to 65

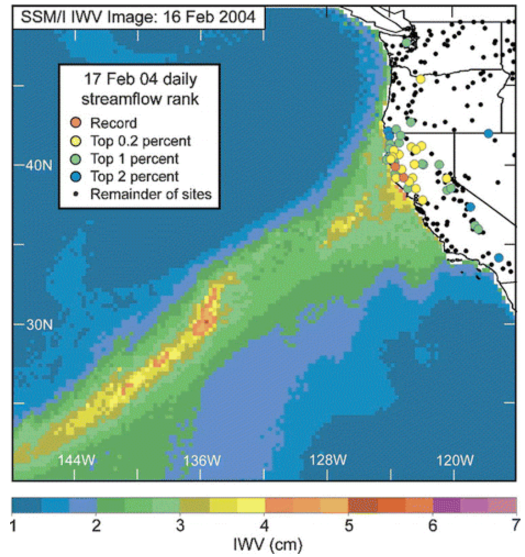
Projections--Interannual Variability



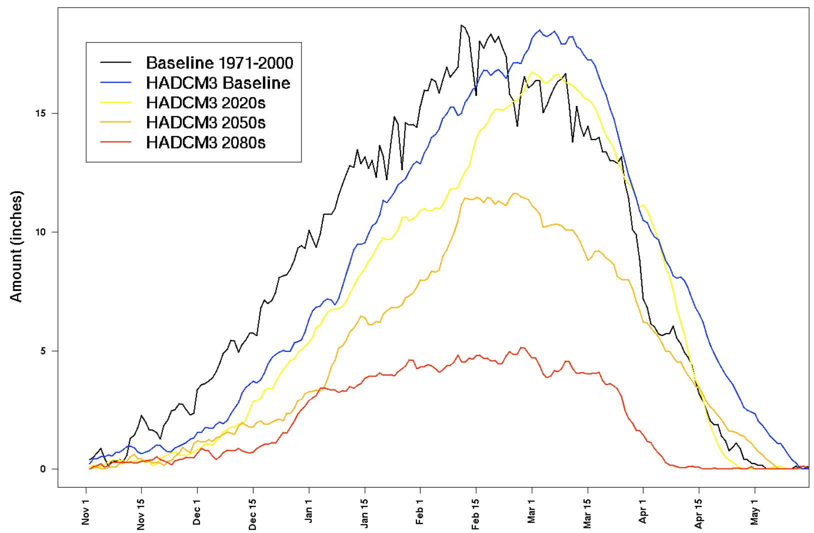
SRES A2 2050s divided by 1980s, standard deviation of annual temperature (°F)

Conclusions and Future Work

- **Conclusions**
  - **The range of results associated with downscaling technique is often smaller than other sources of uncertainty that influence decisions, such as:**
    - **Global climate sensitivity**
    - **Emergent patterns not captured by global climate models**
    - **Interannual to decadal variability**
    - **Climate impacts**
    - **Socio-economic changes**
- **Next Steps**
  - **Analyze pre-conditions for extreme precipitation events in GCMs and RCMs**
  - **Explore standardized statistically downscaled daily products (CMIP3 and CMIP5) such as BCSD, Bias Corrected Constructed Analogues (BCCA; Maurer and Hidalgo, 2008)**
  - **Develop localized downscaling tailored to sector-specific stakeholder needs Statistical Downscaling Model (e.g., SDSM; Wilby et al. 2002)**
  - **Stochastic approaches, weather generators**

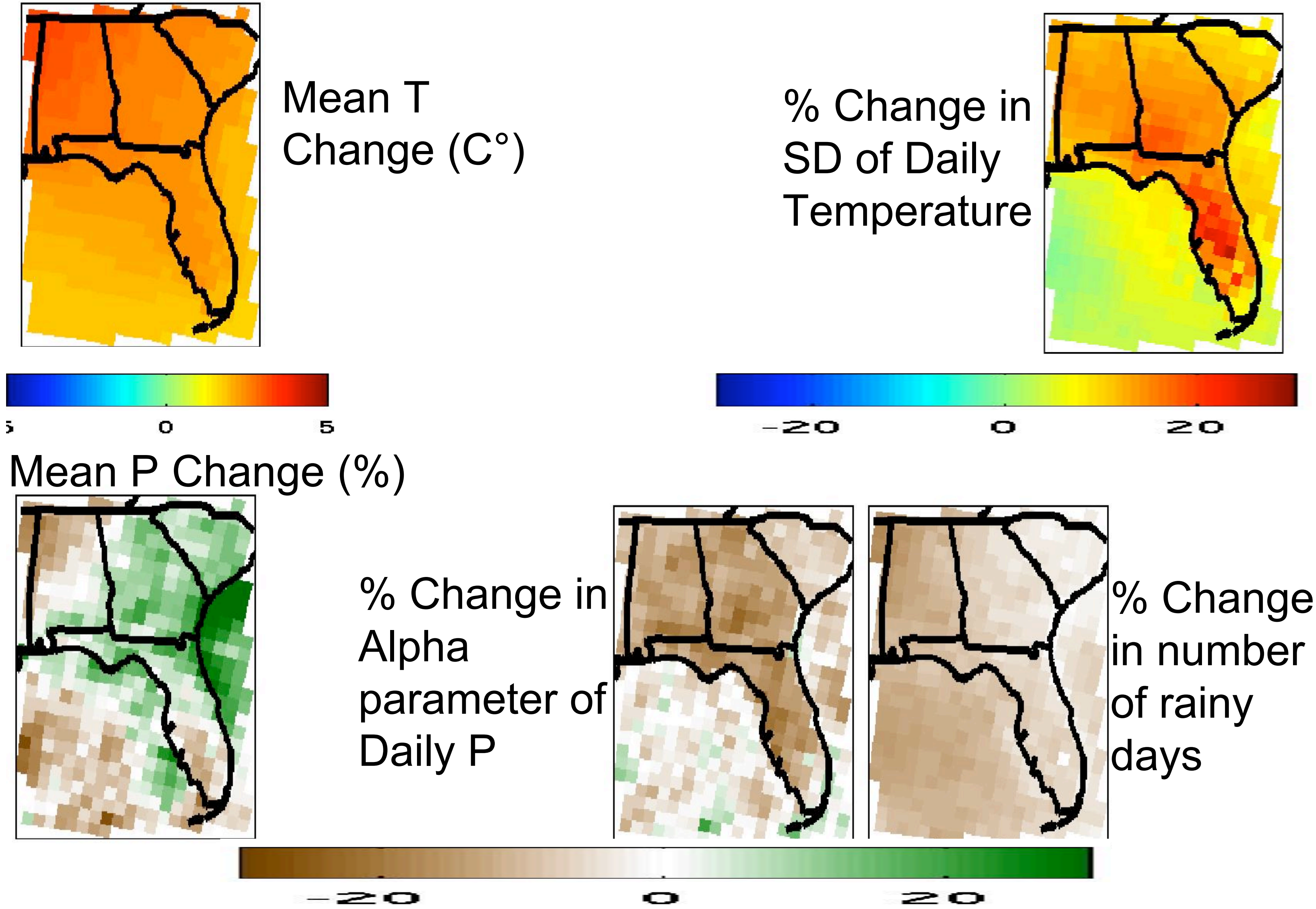


Neiman et al. 2008, Jour. of Hydromet.



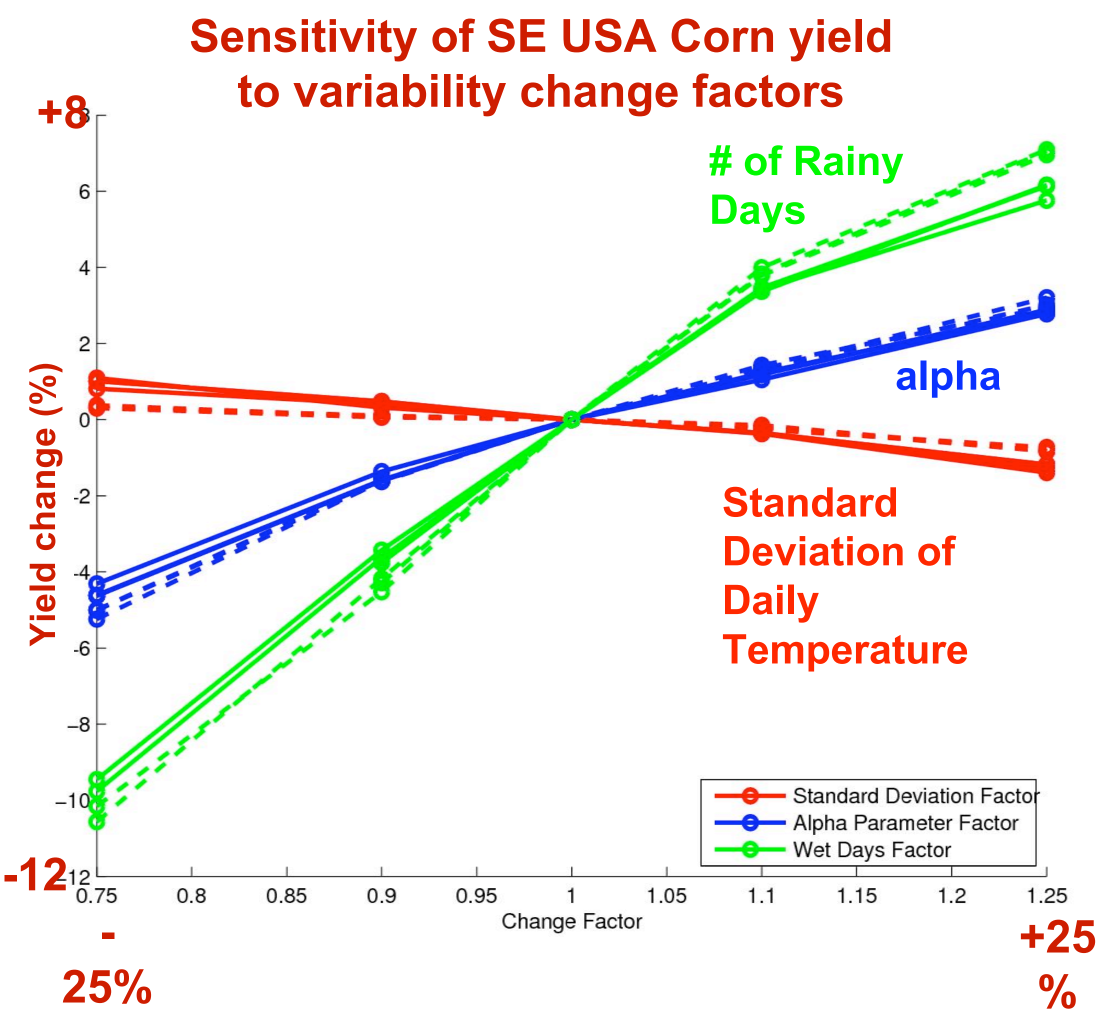
Snow depth at Wanakena, NY based on SDSM downscaling. (Tryhorn and Degaetano in NYState CliMAID Report, to be released in 2011)

GFDL/RCM3 Growing Season Changes, A2 2050s relative to 1980s



Corn Sensitivity to Climate Variability Changes

- **Use stretched distribution approach to impose particular statistical qualities on observed series**
- **Solid lines include interactions between changes in mean and variability**
- **Note that as alpha parameter decreases, rainfall is more extreme**

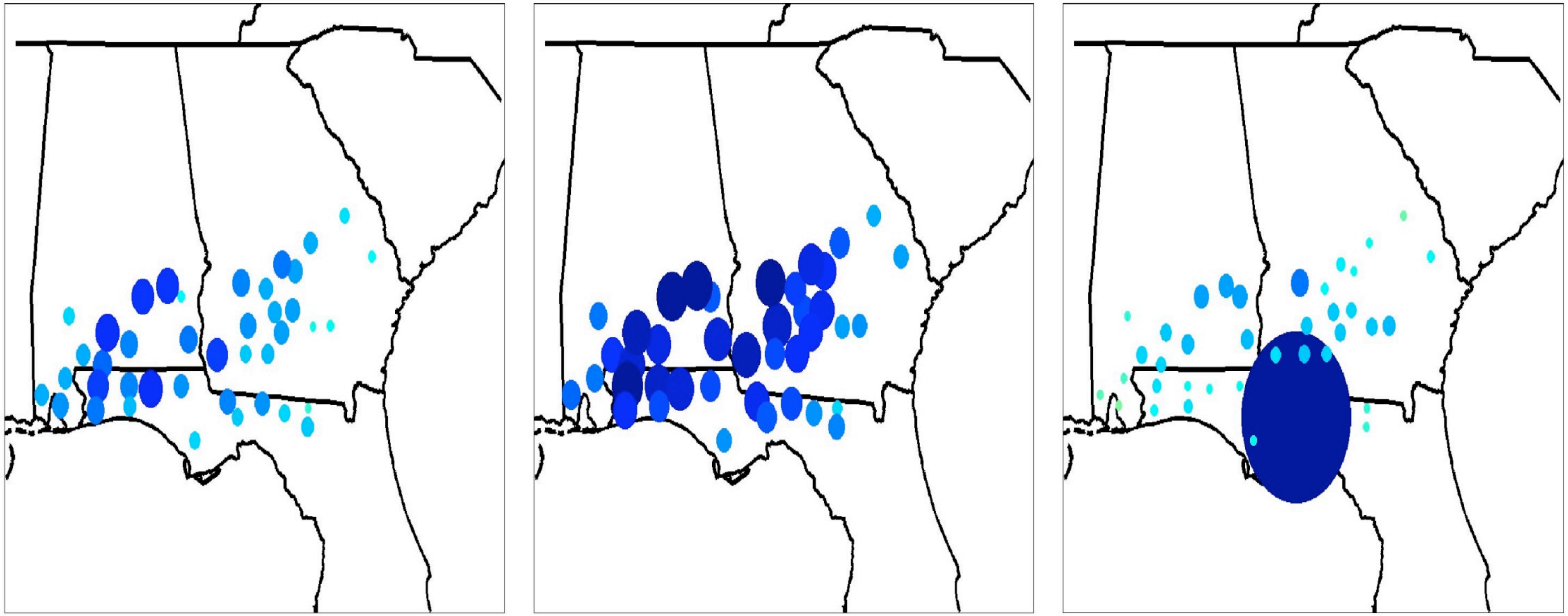


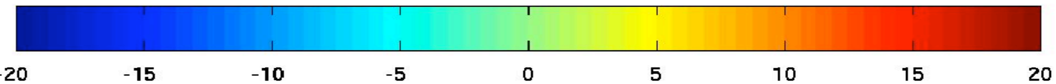
Role of NARCCAP Mean and Variability Changes

a) GFDL/rcm3
Mean changes only

b) GFDL/rcm3
Mean and variability changes

c) GFDL/rcm3
Variability changes only





Impact of variability changes is comparable in magnitude to that of mean changes

- Non-linear, particularly with respect to CO_2 effects during drought

The Agricultural Model Intercomparison and Improvement Project

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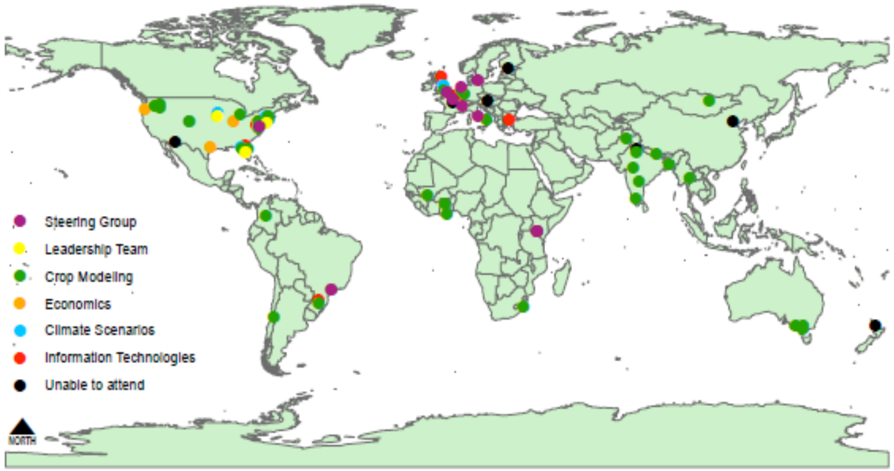
Jim Jones, ***University of Florida***
Jerry Hatfield, ***USDA Agricultural Research Service***
Alex Ruane, ***NASA Goddard Institute for Space Studies***



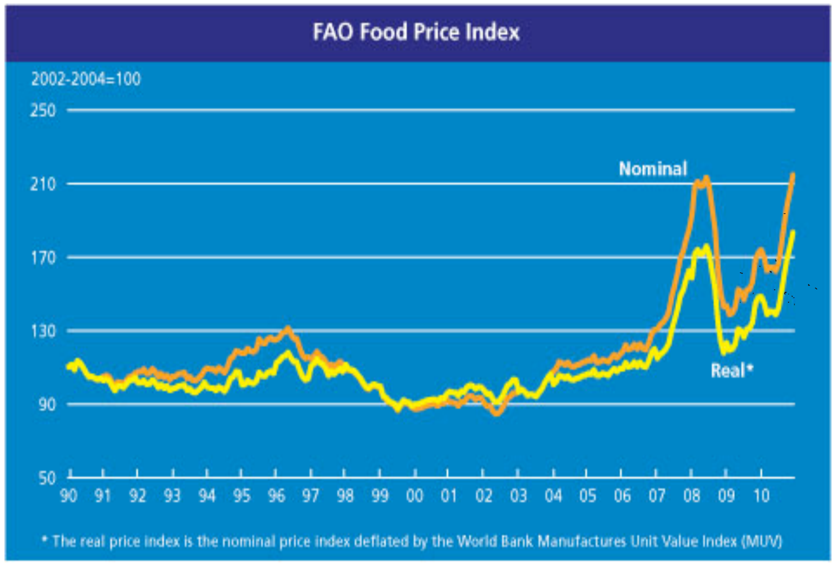
(http://www.agmip.org)

Thanks to DFID, USDA and CCAFS for funding

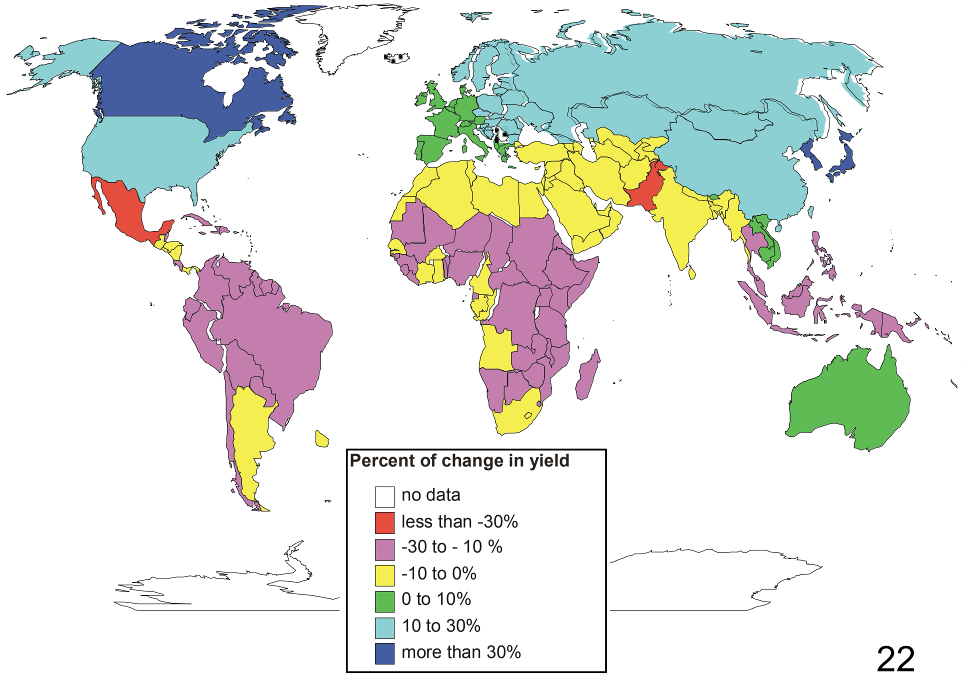
AgMIP The Agricultural Model Intercomparison and Improvement Project

Why AgMIP?

- **Food security and climate change**
  - How will climate affect agriculture in developing regions?
  - Many studies assume declining food prices
  - Recent food crises and extreme events question this assumption
- **Capacity building**
  - Developing country agricultural regions and crops still understudied
  - Local researcher capacity needed to lead future assessments and adaptive planning



Source: FAO



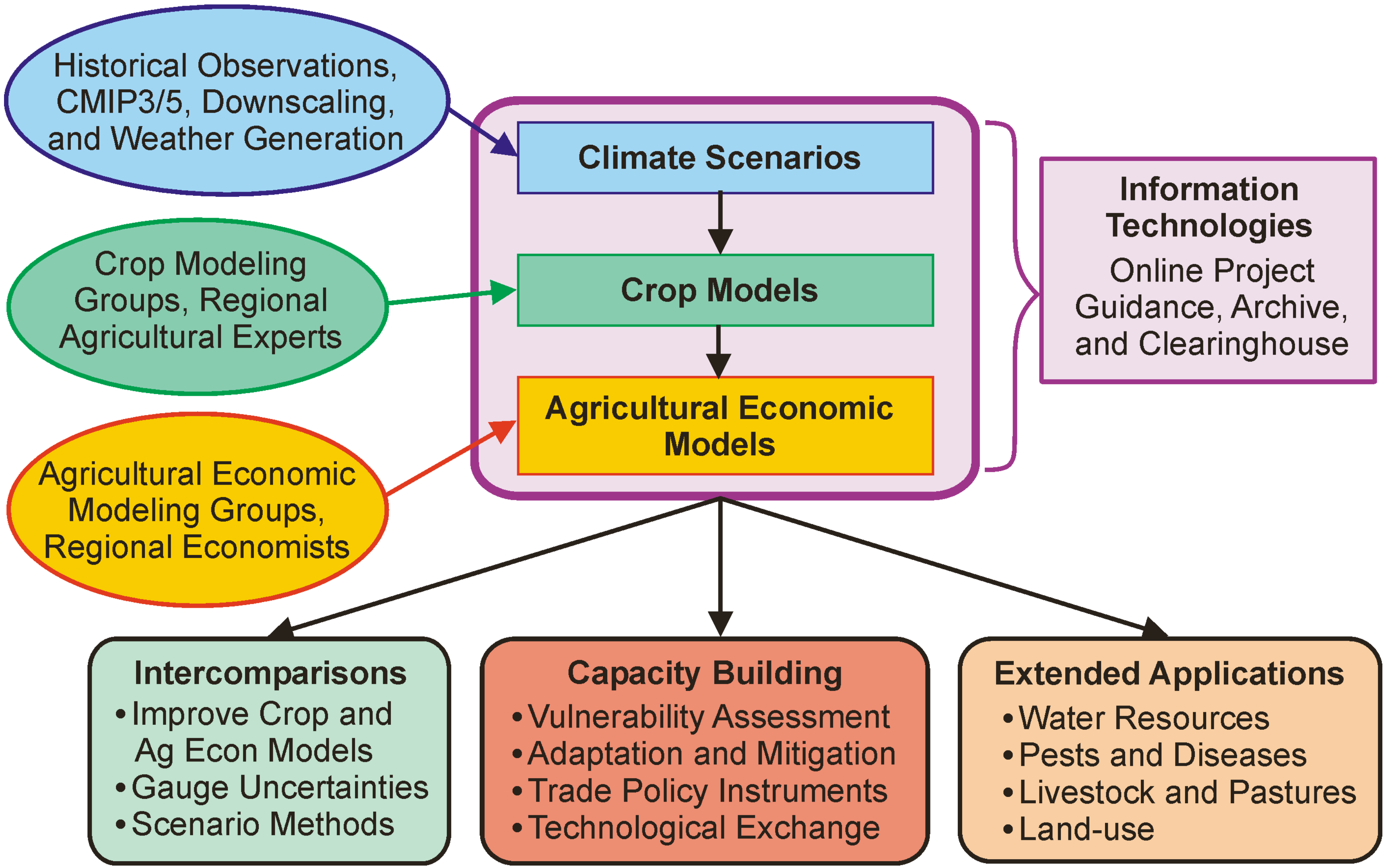
Based upon Rosenzweig and Parry, 1994

AgMIP Objectives

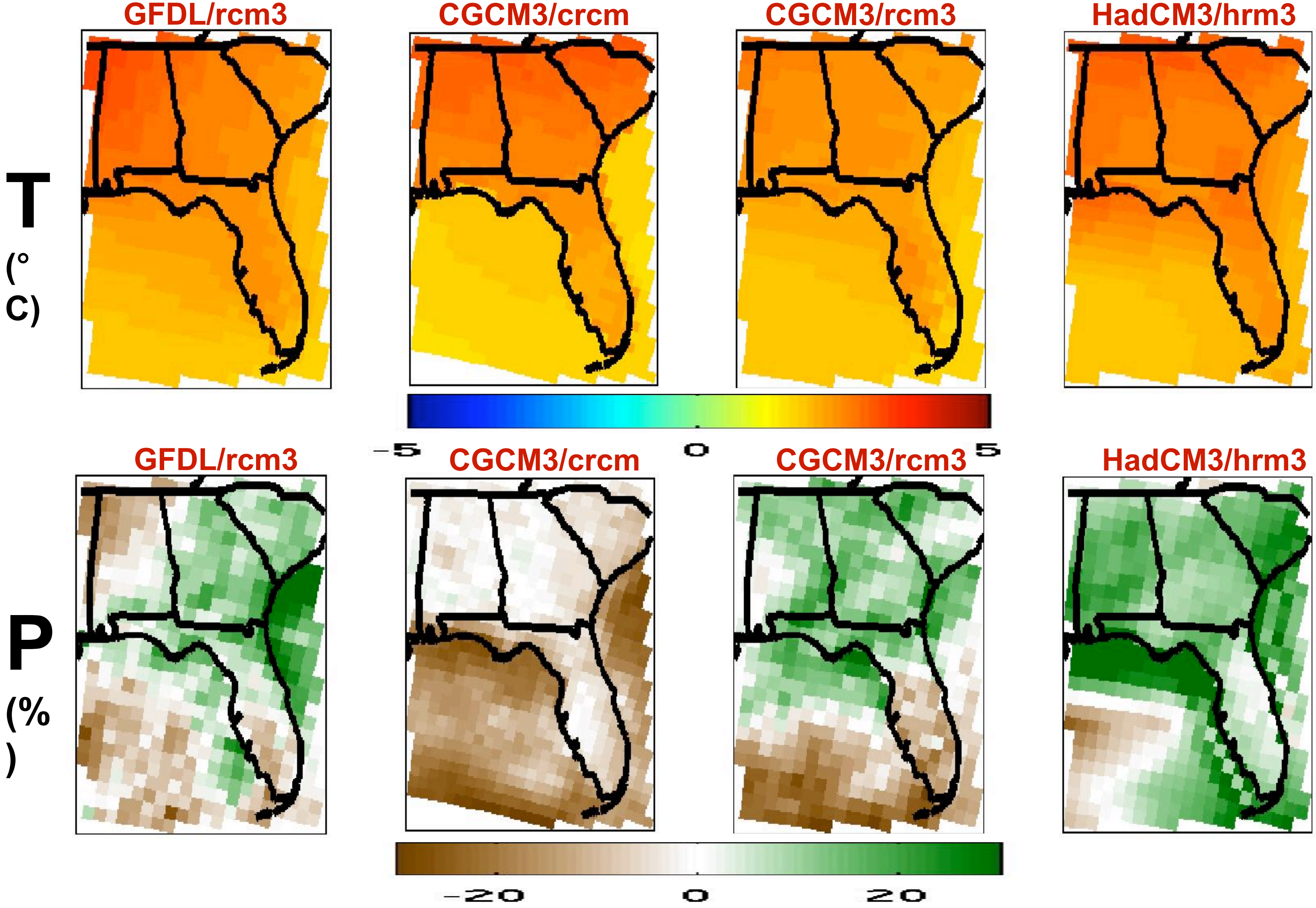
- Improve scientific and adaptive capacity of major agricultural regions in developing and developed world
- Collaborate with regional experts in agronomy, economics, and climate to build strong basis for applied simulations addressing key regional questions
- Develop framework to identify and prioritize regional adaptation strategies
- Incorporate crop and agricultural trade model improvements in coordinated assessment of future climate conditions
- Include multiple models, scenarios, locations, crops and participants
- Understand roles of land use and mitigation
- Link to key on-going efforts
  - CGIAR/ESSP, CCAFS, Global Futures, MOSAICC, others
  - IPCC AR5




AgMIP Elements and Linkages



NARCCAP mean growing season changes



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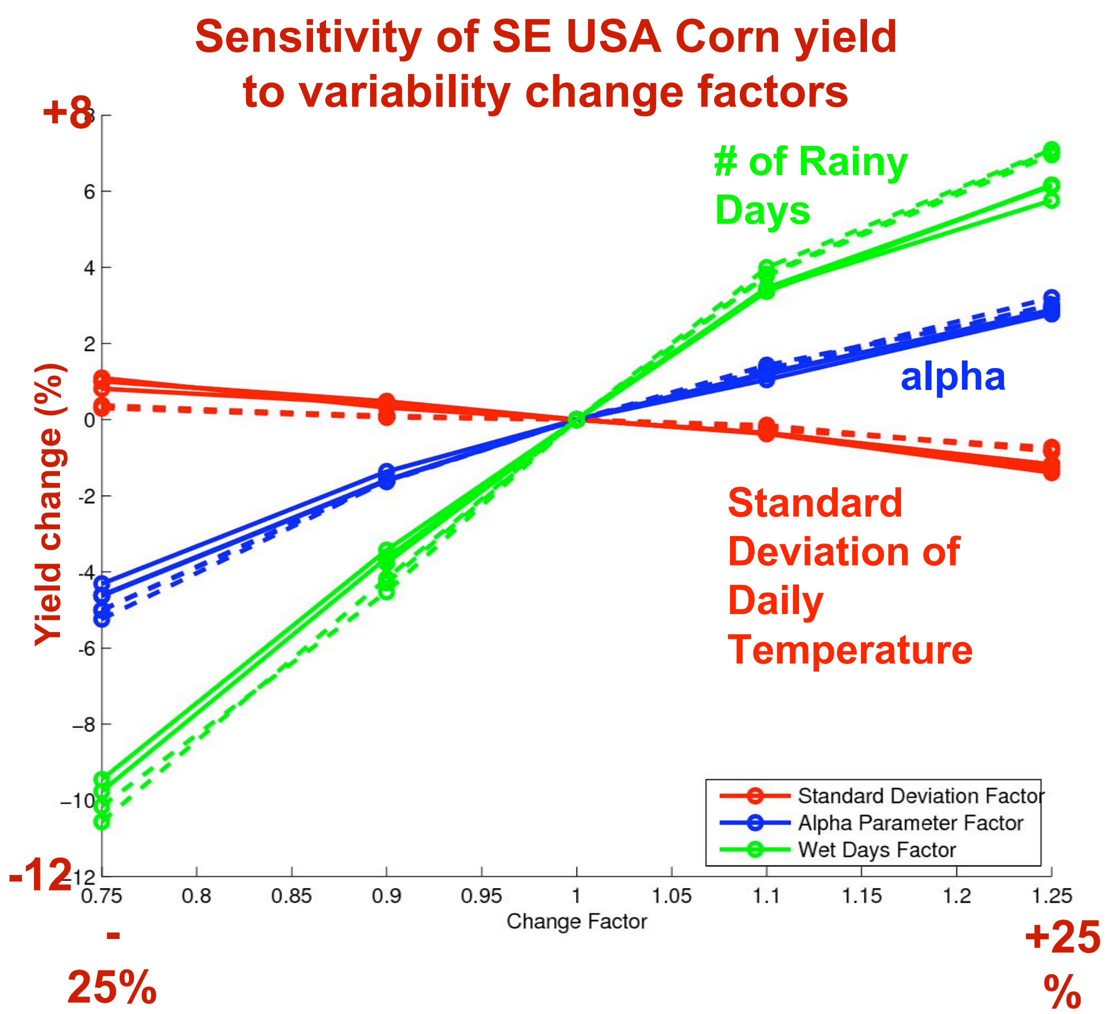
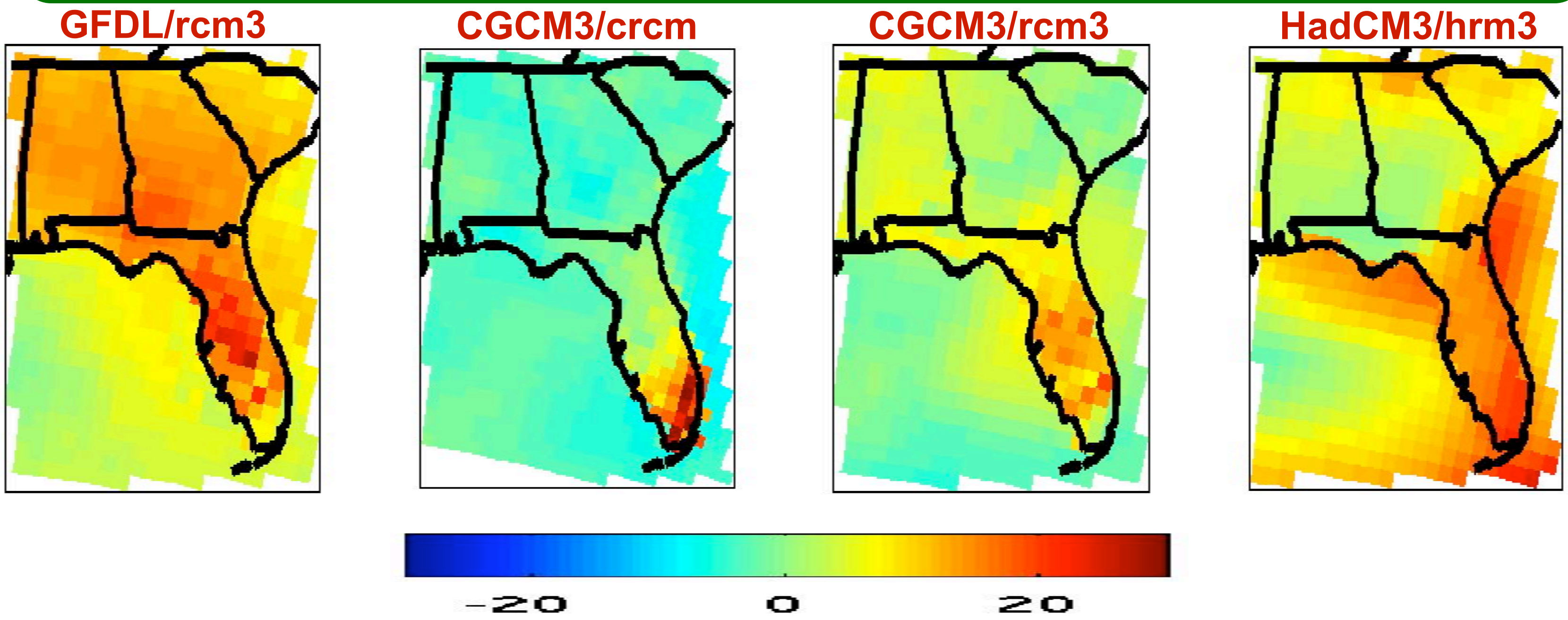
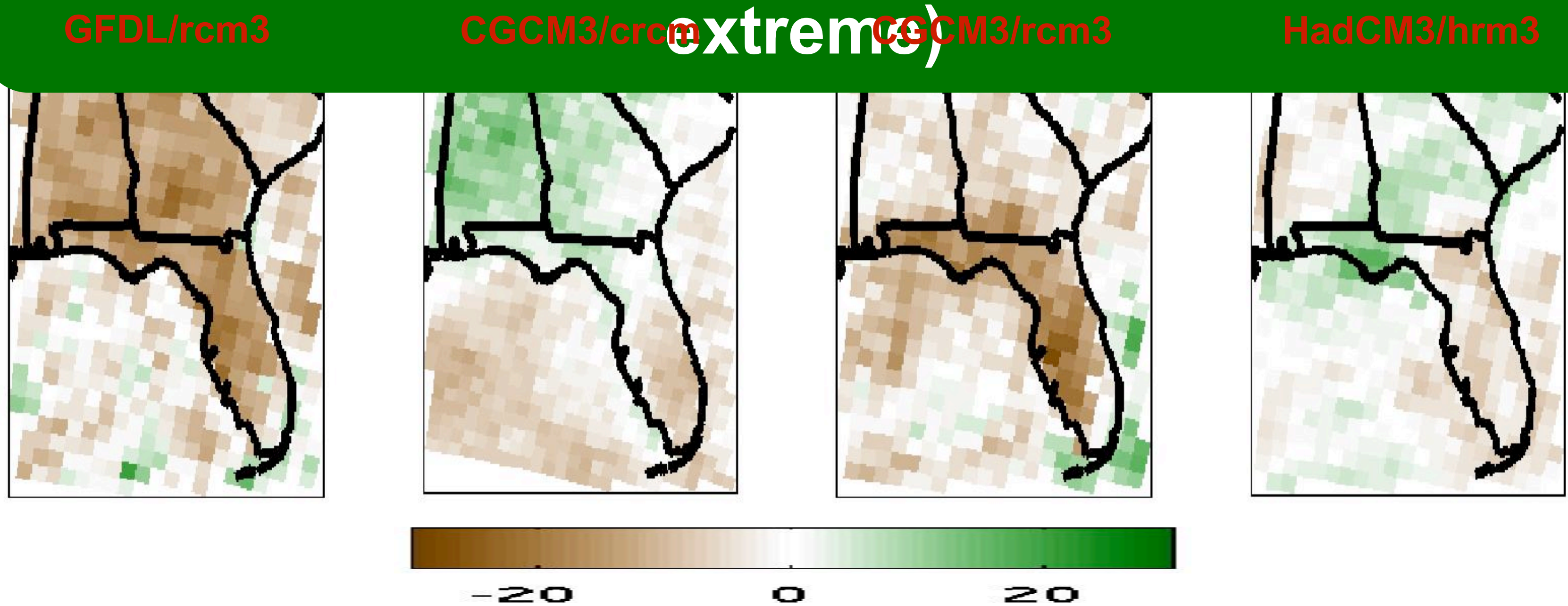


NARCCAP % changes in standard deviation of growing season daily temperature



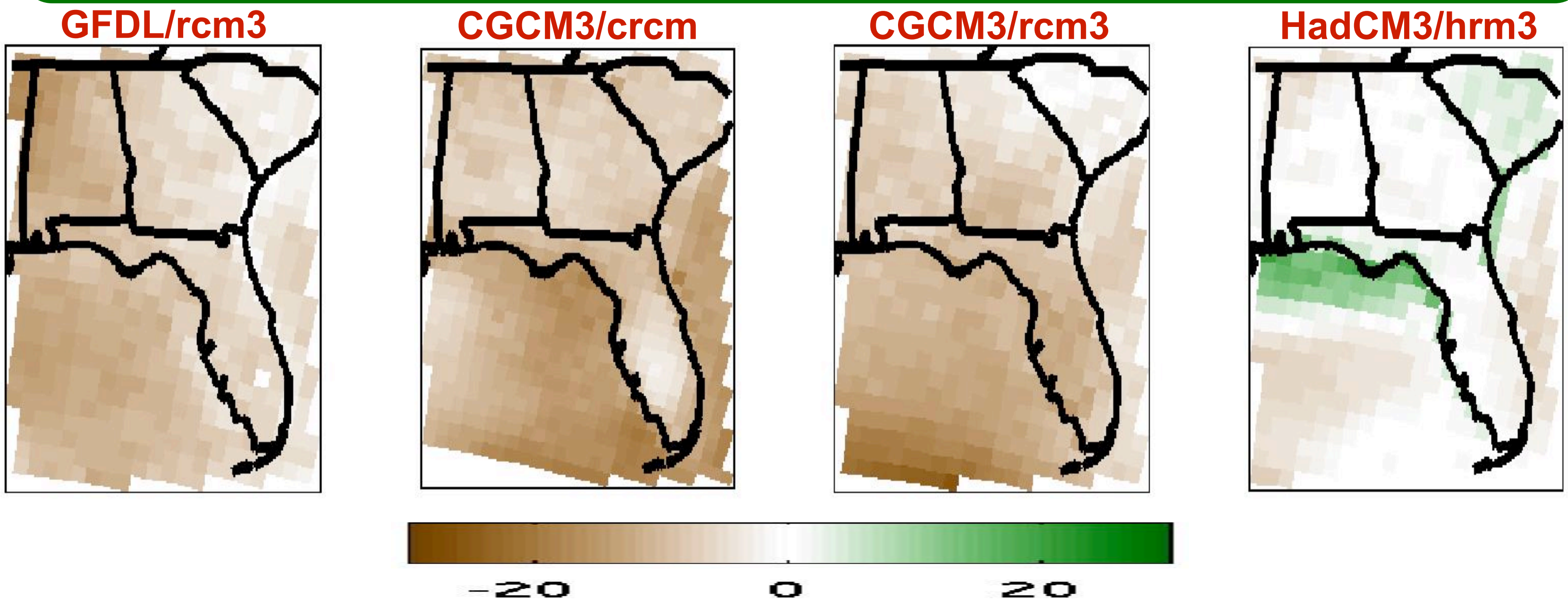
Except for CGCM3/crcm, standard deviation of temperature generally increasing

NARCCAP % changes in growing season rainfall distribution's alpha parameter (lower = more extreme)



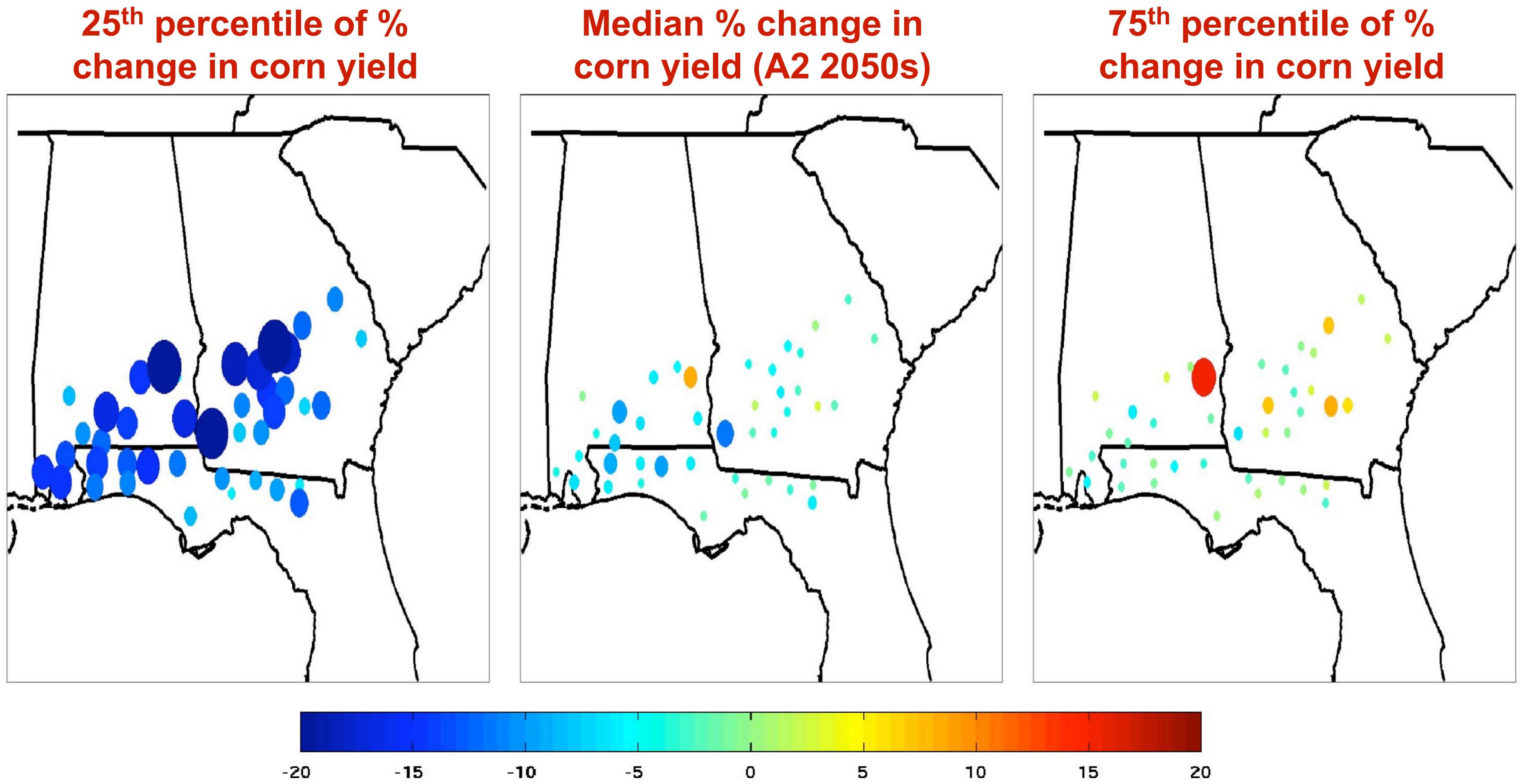
RCM3 simulations producing more extreme distribution of rainfall

NARCCAP % changes in number of rainy days in growing season



Decrease in number of wet days projected for almost all land areas in all models

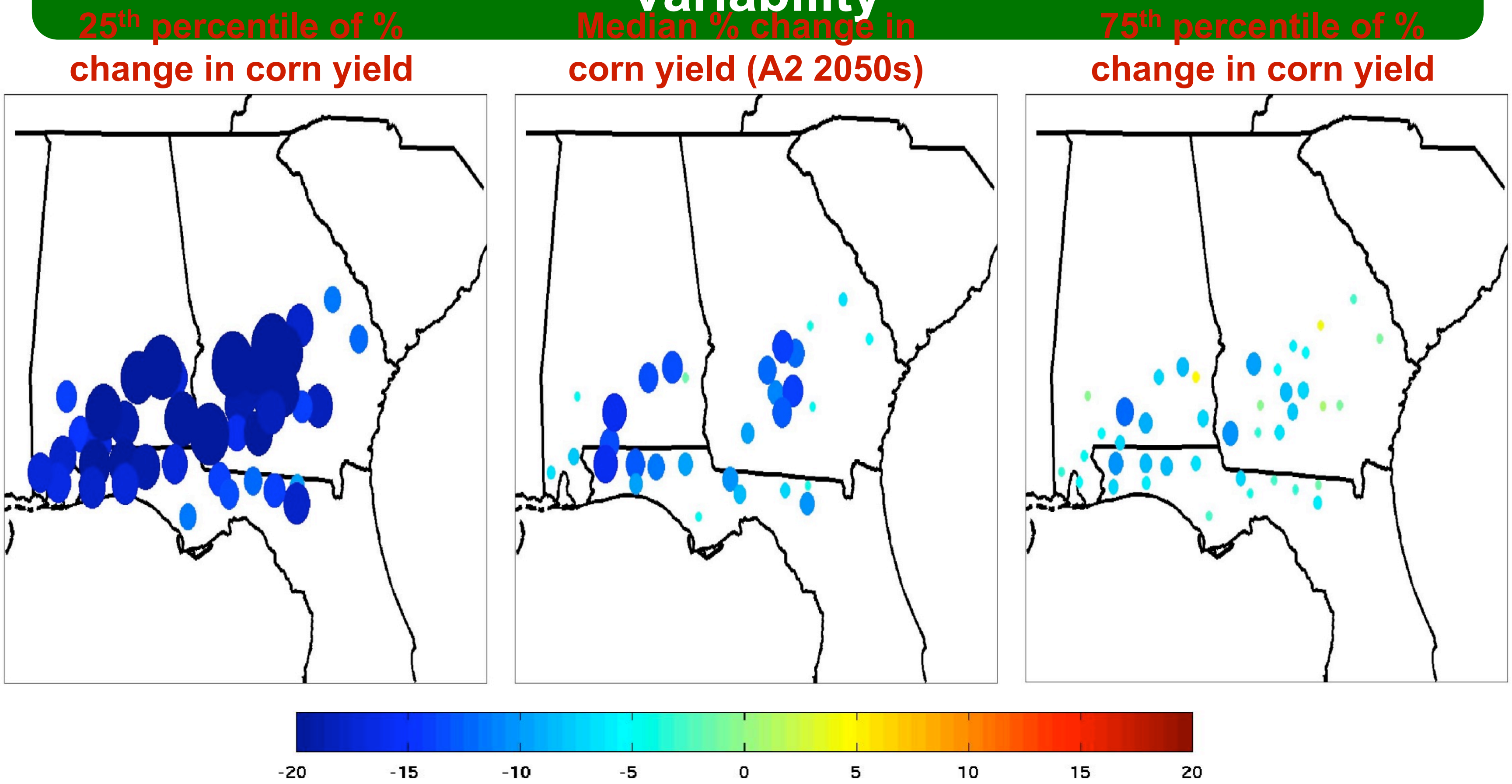
GCM Ensemble Projections



No variability changes

- **Imposes mean changes entirely on intensity of storms, not frequency**

Projections of GCM Ensemble with NARCCAP variability



Results from 16 GCM ensemble, with GCM mean changes and variability changes imposed from 4 NARCCAP runs (64 ensemble members)

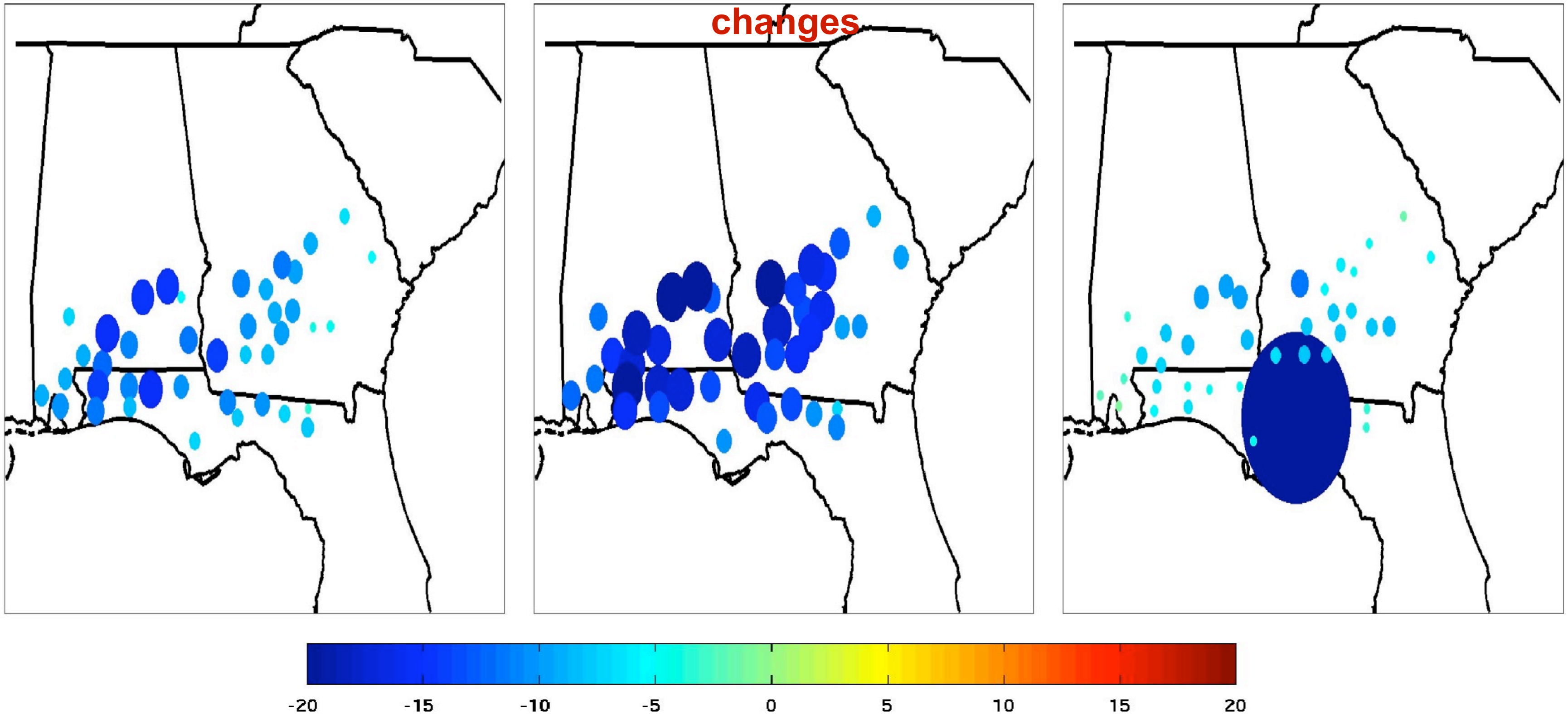
- **Including higher-frequency variability from NARCCAP results in a more pessimistic projection of future corn yields across Southeast.**

Role of NARCCAP Mean and Variability Changes

a) GFDL/rcm3
Mean changes only

b) GFDL/rcm3
Mean and variability changes

c) GFDL/rcm3
Variability changes only



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- Non-linear, particularly with respect to CO_2 effects during drought