Climate science and agriculture: What is CSCAP's approach?

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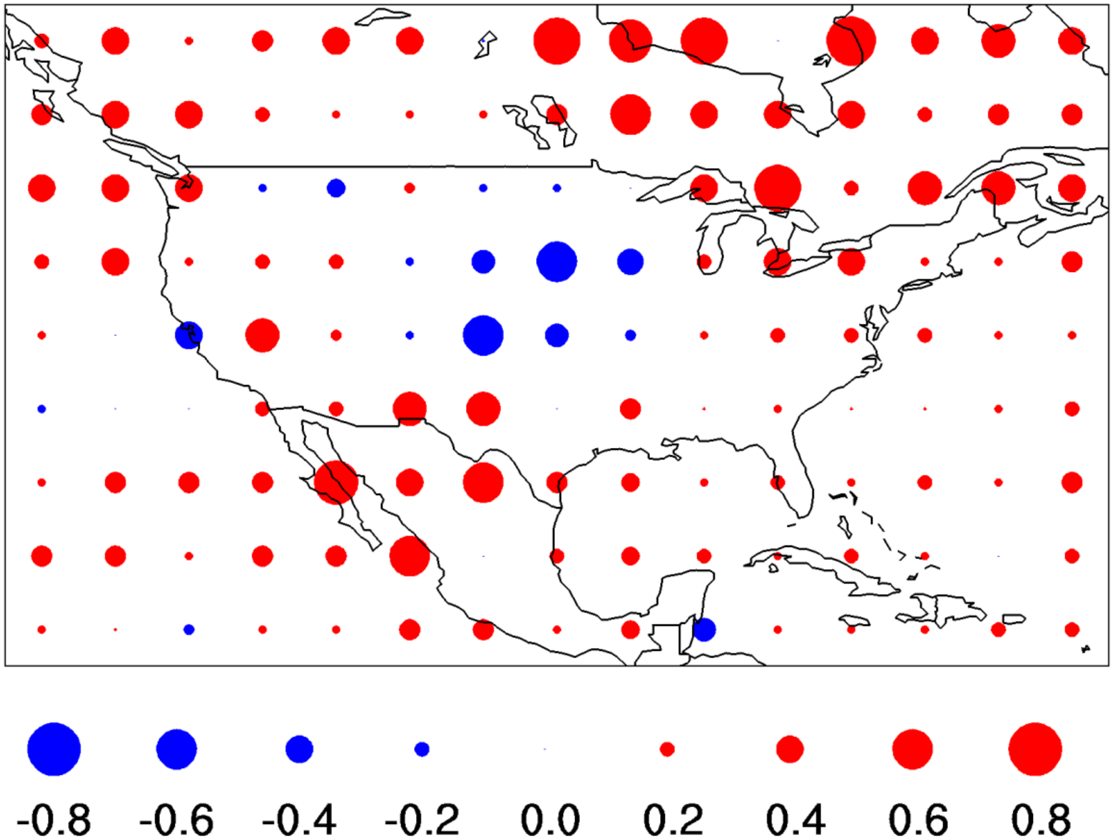
Outline

- Recent trends in Midwest climate and their effects on agriculture.
- Climate projections: approaches and limitations.
- Using climate projections in CSCAP.

Climate Change in the Central U.S.

Observed Summer Daily Maximum Temperature Changes (K), 1976-2000



The central U.S. has been a summertime "warming hole."

Adapted from Folland et al. [2001]

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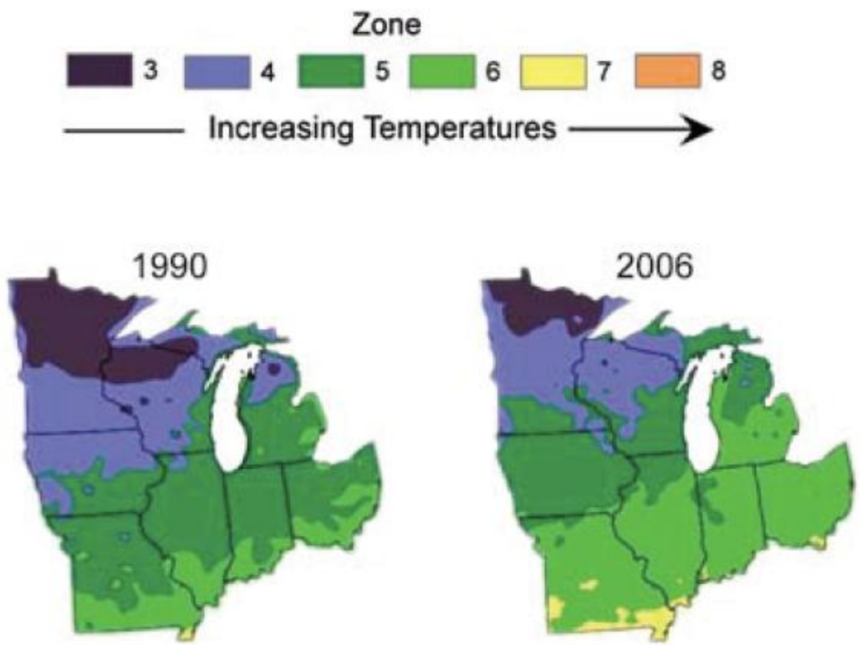
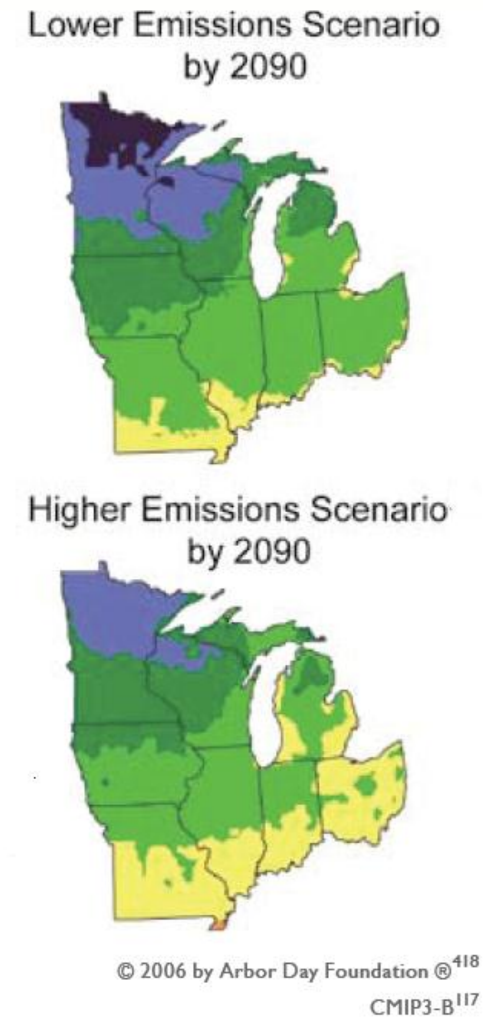
Hardiness zones are creeping northward



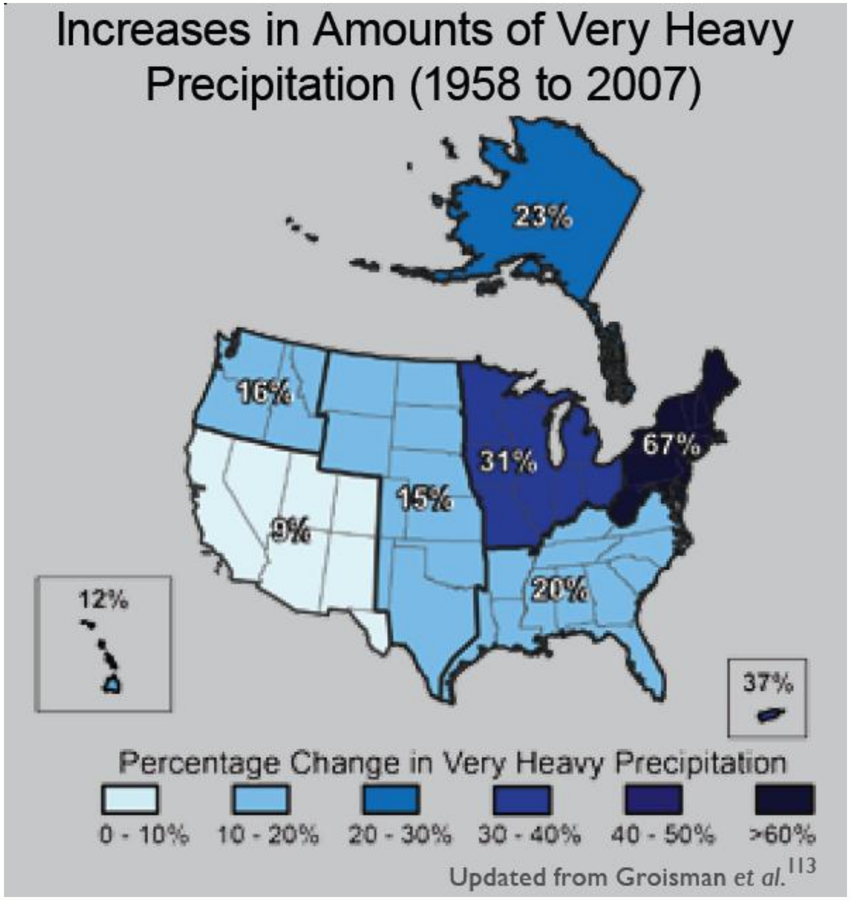


- Shift of about 1/2 to 1 full zone every 30 years.
- Each zone represents a 10ºF range in lowest temperature of the year.

Karl, T. R., J. M. Melillo, and T. C. Peterson, (eds.), 2009: Global Climate Change Impacts in the United States. Cambridge University Press, 2009, 196pp.

Multiple "100 year" floods since 1993

“**One of the clearest trends** in the United States observational record is an **increasing frequency and intensity of heavy precipitation events**… Over the last century there was a 50% increase in the frequency of days with precipitation over 101.6 mm (4") in the upper midwestern U.S.; this trend is statistically significant.“



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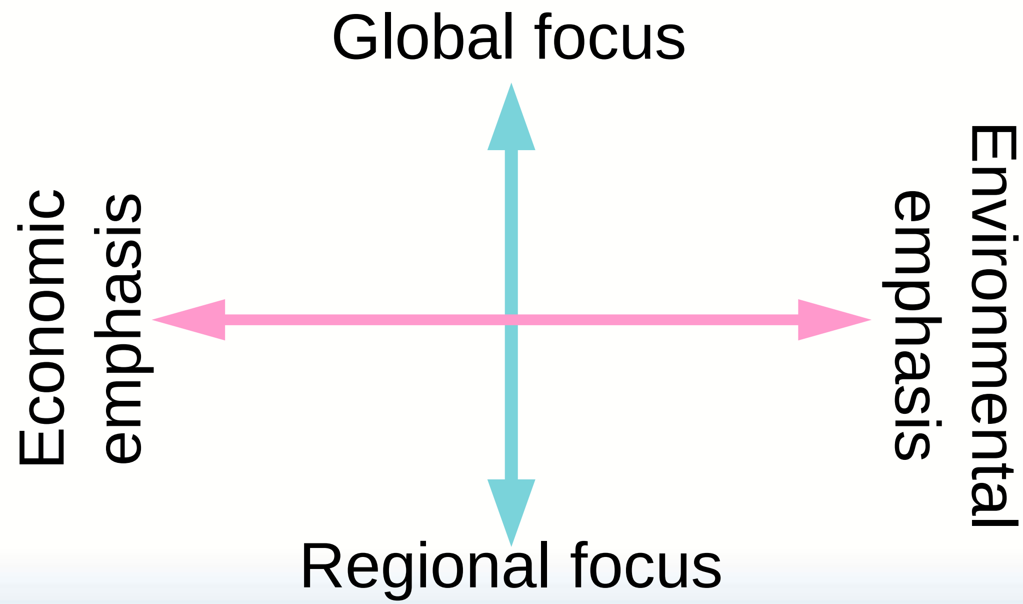
Iowa farmers are adapting

- Longer growing season: plant earlier, plant longer season hybrids, harvest later
- Wetter springs: larger machinery enables planting in smaller weather windows
- Waterlogged soils in spring: shallow root system more prone to disease, nutrient deficiencies and drought; risk of compaction, delayed planting and pest control
- Wetter springs and summers: more subsurface drainage tile, closer spacing, sloped surfaces
- Fewer extreme heat events: higher planting densities, fewer pollination failures
- Higher humidity: more spraying for pathogens, more problems with fall crop dry-down, wider bean heads for faster harvest due to shorter daytime harvest period

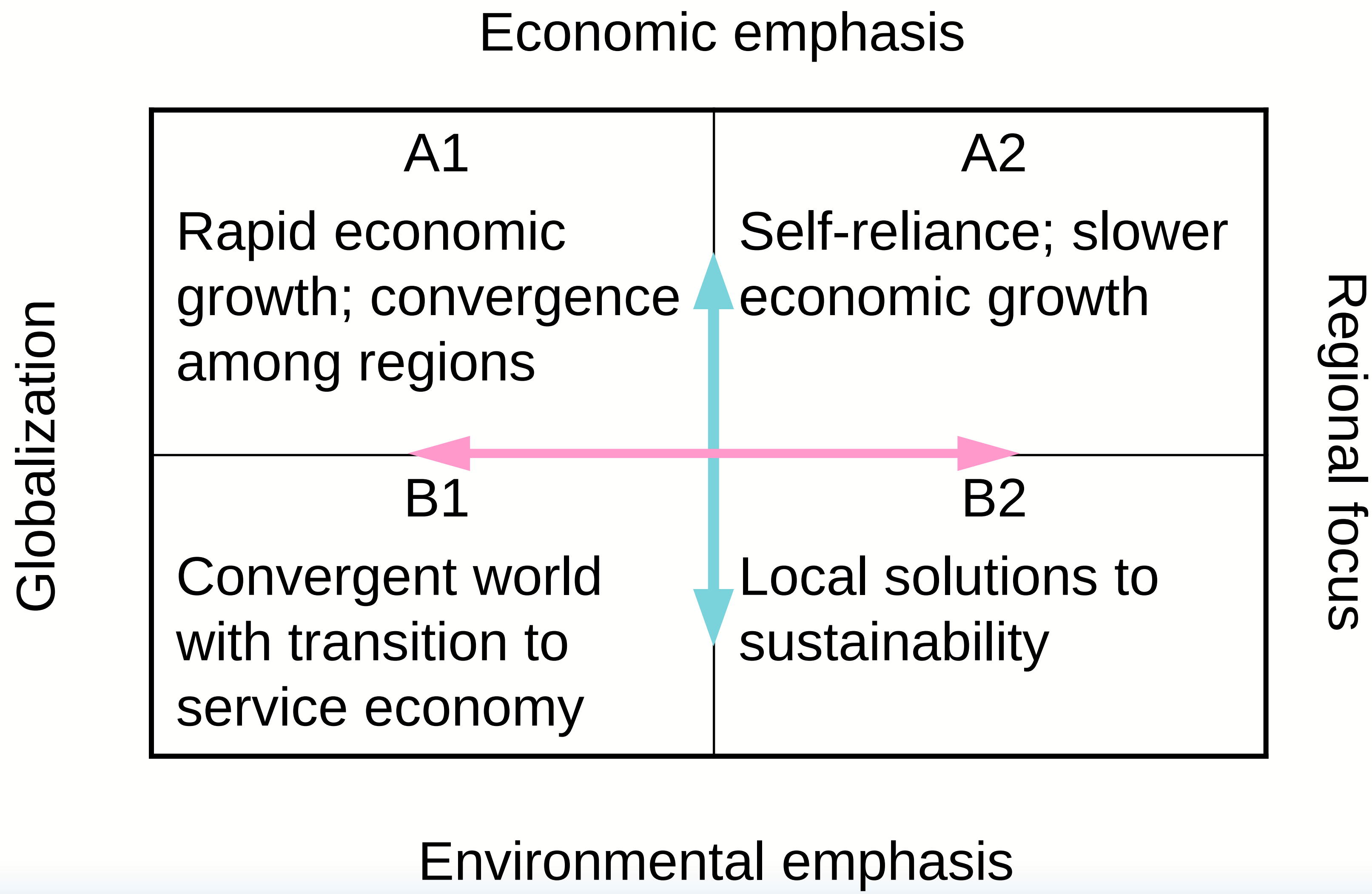
(per Rick Cruse, ISU Agronomy)

What will the future be like?

- Emissions scenarios are developed from storylines.
- Two main considerations:
  – Global versus regional/national
  – Economic versus environmental

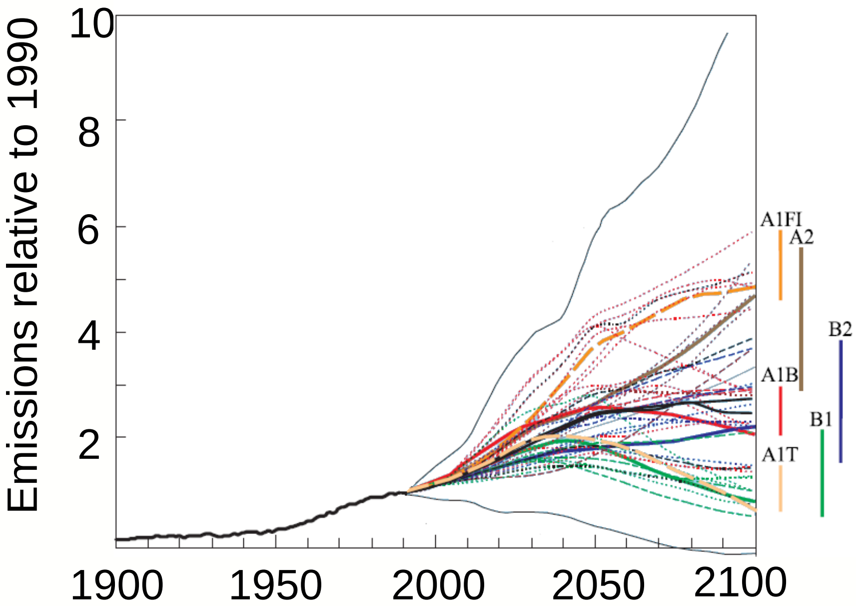


IPCC storylines



From storylines to emissions scenarios

- The four storylines yield four families of emissions scenarios.
- Example: The A1 storyline (rapid economic growth with convergence among regions) includes three emissions scenario groups:
  - A1FI: Fossil fuel intensive
  - A1T: Predominantly non-fossil fuel
  - A1B: Balanced
- There is no "most likely" scenario.



Global climate models

- Greenhouse gas concentrations from emissions scenarios are input to global climate models.
  - Climate models are based on physical principles: absorption and emission of radiant energy, laws of thermodynamics, Newton's laws of motion, etc.
- **There is no single best climate model** for all periods, locations and variables. This is one of the most robust conclusions from model evaluation studies.
  - Applications should use results from a range of climate models.

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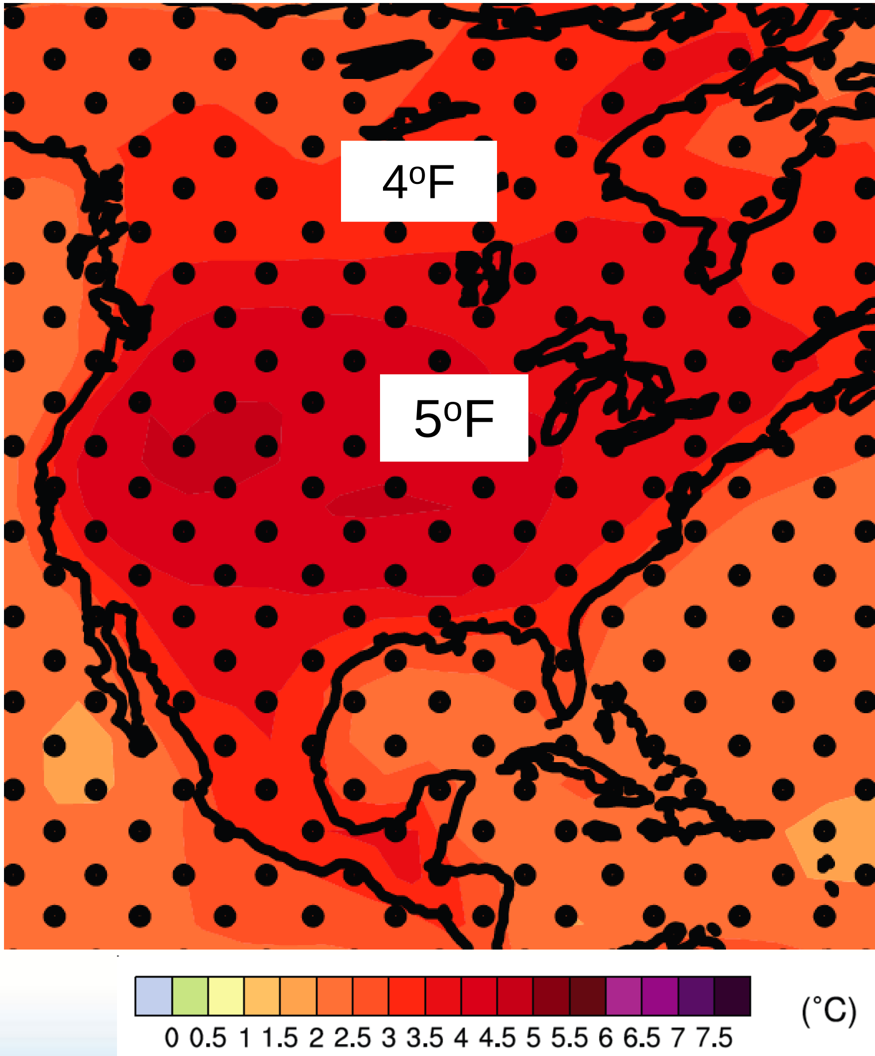
Projected summer temperature change



A1B Emission Scenario 2080-2099 minus 1980-1999

Dotted areas show where more than 90% of models agree on the sign of the change

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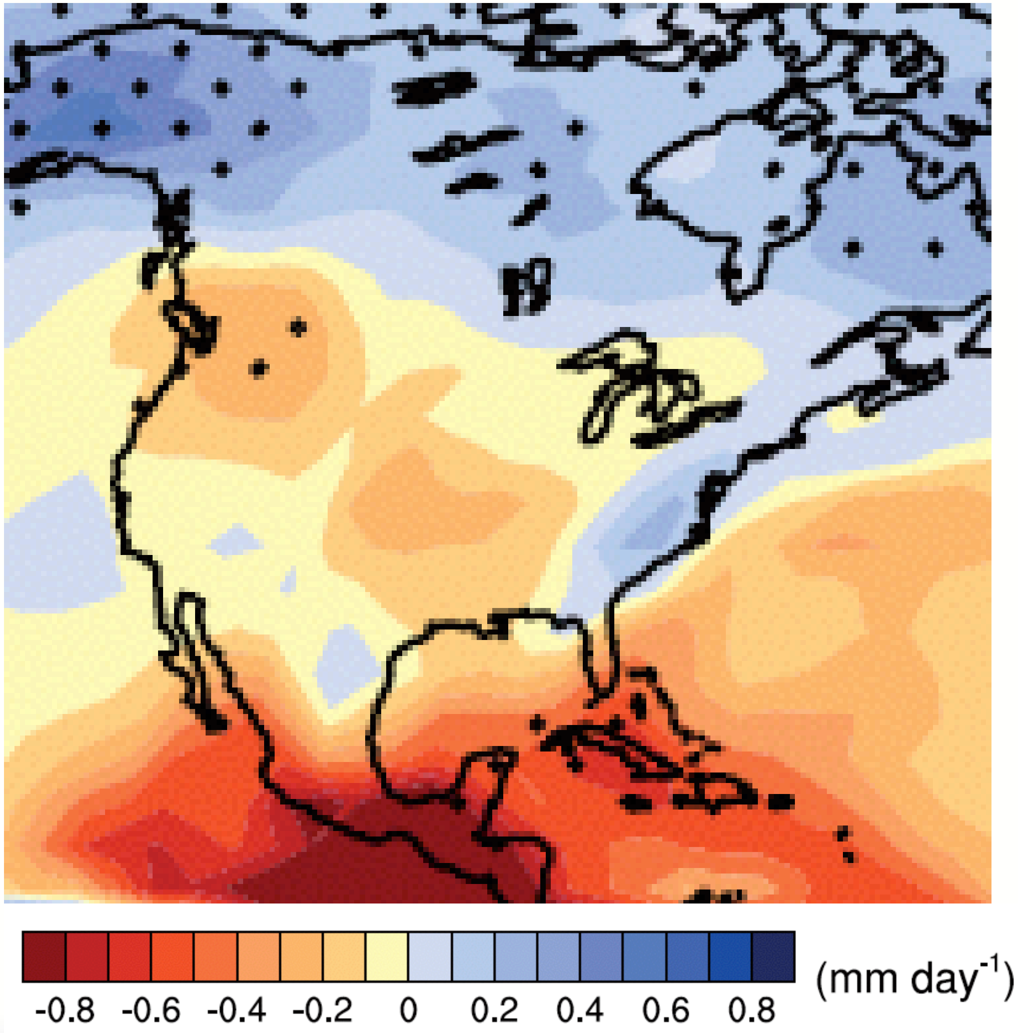
Projected summer precipitation change



A1B Emission Scenario 2080-2099 minus 1980-1999

Note less model agreement compared with temperature.

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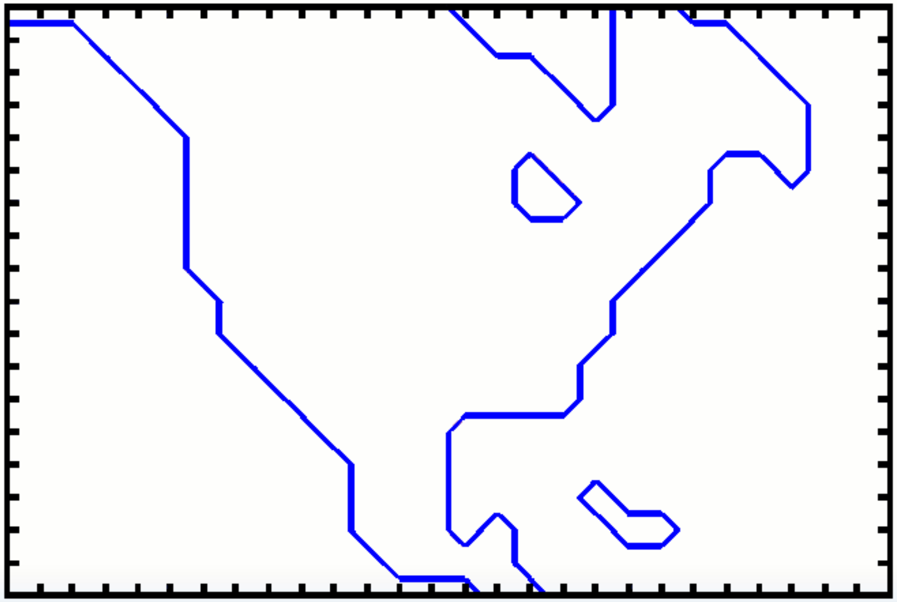
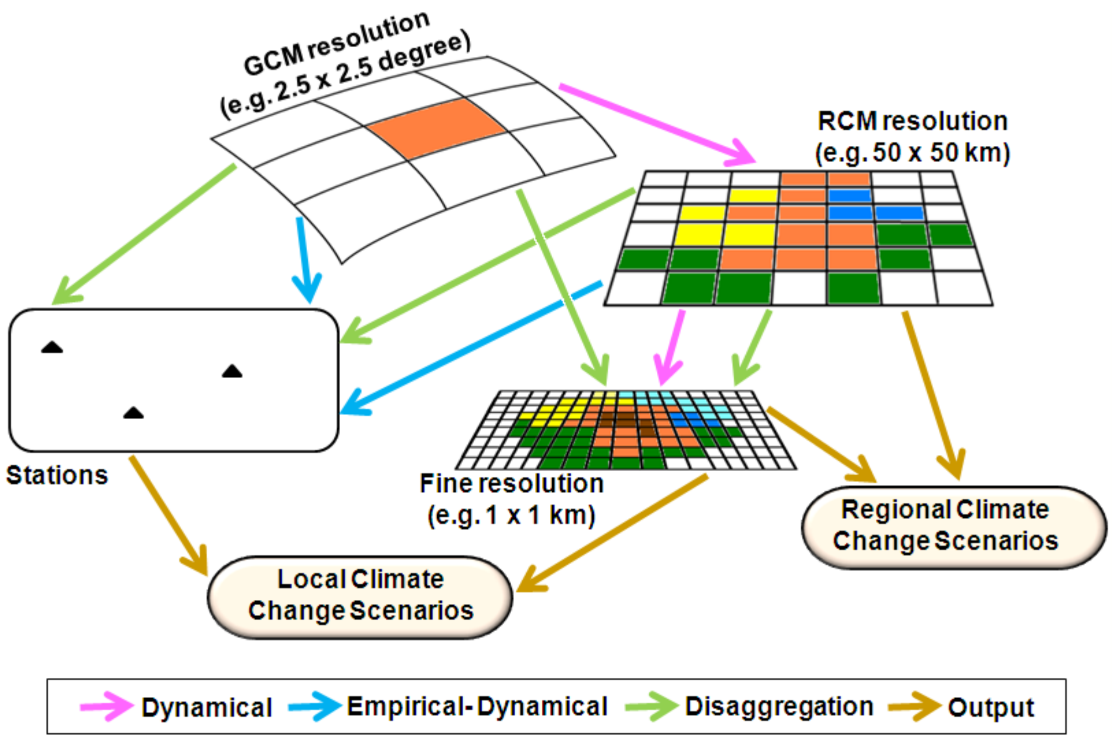
Global models have coarse grids

- A problem: The equations have to be solved over the whole globe, every few minutes, for hundreds of years.
  - Computer limitations mean the equations are solved at points too far apart for many practical applications.

Land-sea boundaries in the UK Hadley Centre Coupled Model version 3 (HadCM3), grid 2.5º latitude by 3.75º longitude.



Downscaling



(from Winkler et al. 2011)

- Most applications (including agriculture) need data at finer spatial scales than provided by global climate models.
- **Downscaling** methods are used to derive fine-scale climate information.

Climate in the CSCAP

- CSCAP investigators will calibrate their process and impacts models using observed data, then use climate projections to make inferences about the future.
  - Projections from several climate models will be used to sample the range of plausible future climates.
- CSCAP investigators have access to climate observations, simulations, and projections:
  - Iowa Environmental Mesonet and other sources for observed data.
  - Archived simulations and projections from IPCC Fourth Assessment Report global climate models.
  - Downscaled simulations and projections from several sources (NARCCAP, Bureau of Reclamation, others).

Climate in the CSCAP

- CSCAP has connections with other national and international projects:
  - U.S. National Climate Assessment; various climate modeling and downscaling projects
  - Agricultural Model Intercomparison and Improvement Project (AgMIP)
  - Other USDA projects (U2U, other USDA CAPs)
- Cooperation will benefit in sharing data, methods and lessons learned.