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Scenarios from Regional Climate Models: More Uncertainty or Better Information (or Both)?

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Workshop on Uncertainty in Climate Change Research: An Integrated Approach

NCAR, Boulder, CO

August 15, 2012

Uncertainties about Future Climate

- The future trajectory of emissions of greenhouse gases (based on uncertainties about how the world will develop economically, socially, politically, technologically)
  - Explored through the development of scenarios of future world development (**O'Neill presentation**)
- How the climate system responds to increasing greenhouse gases (**Forest, Sexton, Sanderson, Collins presentations**)
  - Explored through use of climate models
  - Spatial scale at which climate models are run is an additional source of uncertainty
- The natural internal variability of the climate system (**Deser presentation**)

Global Temperature Change using new scenarios for AR5

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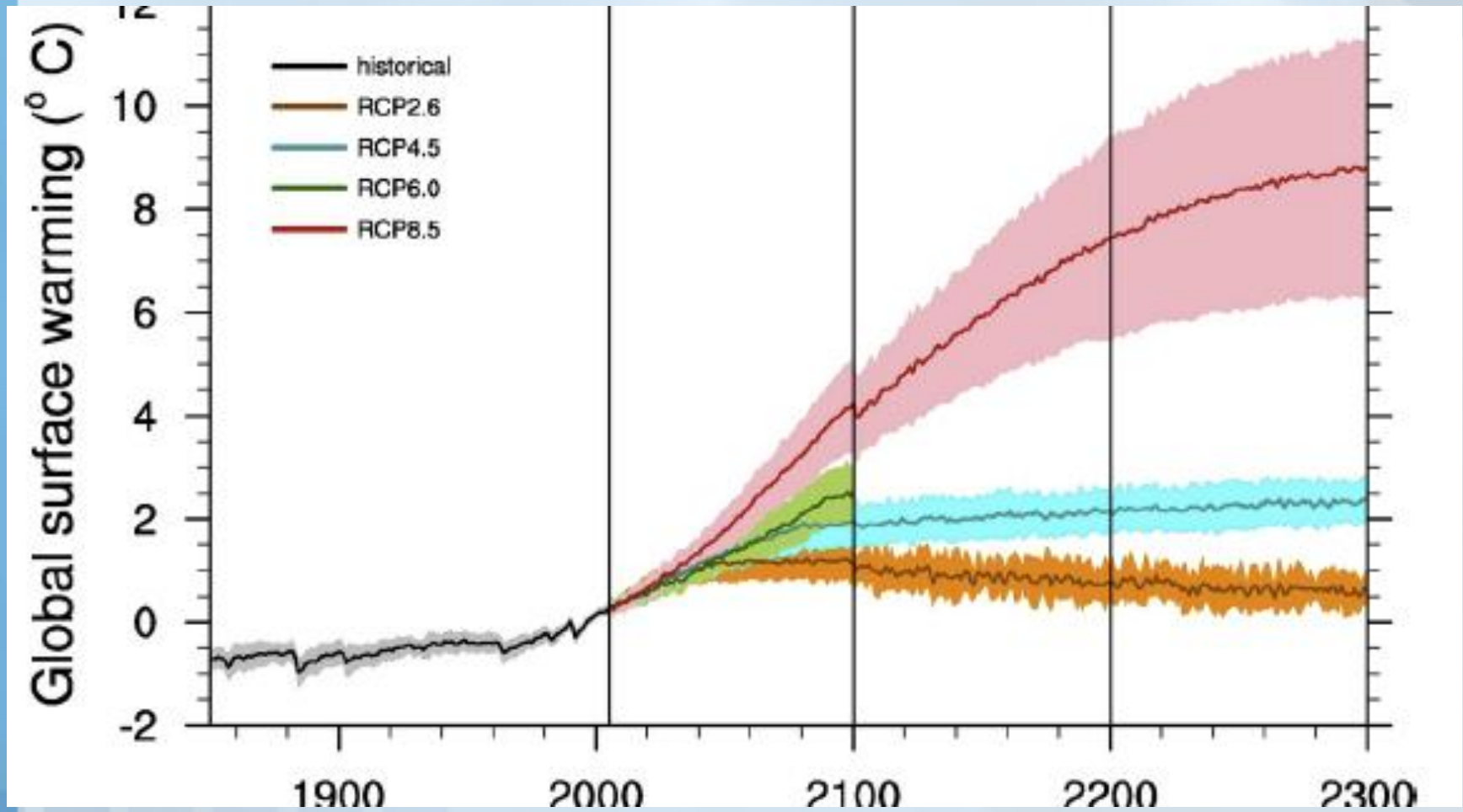
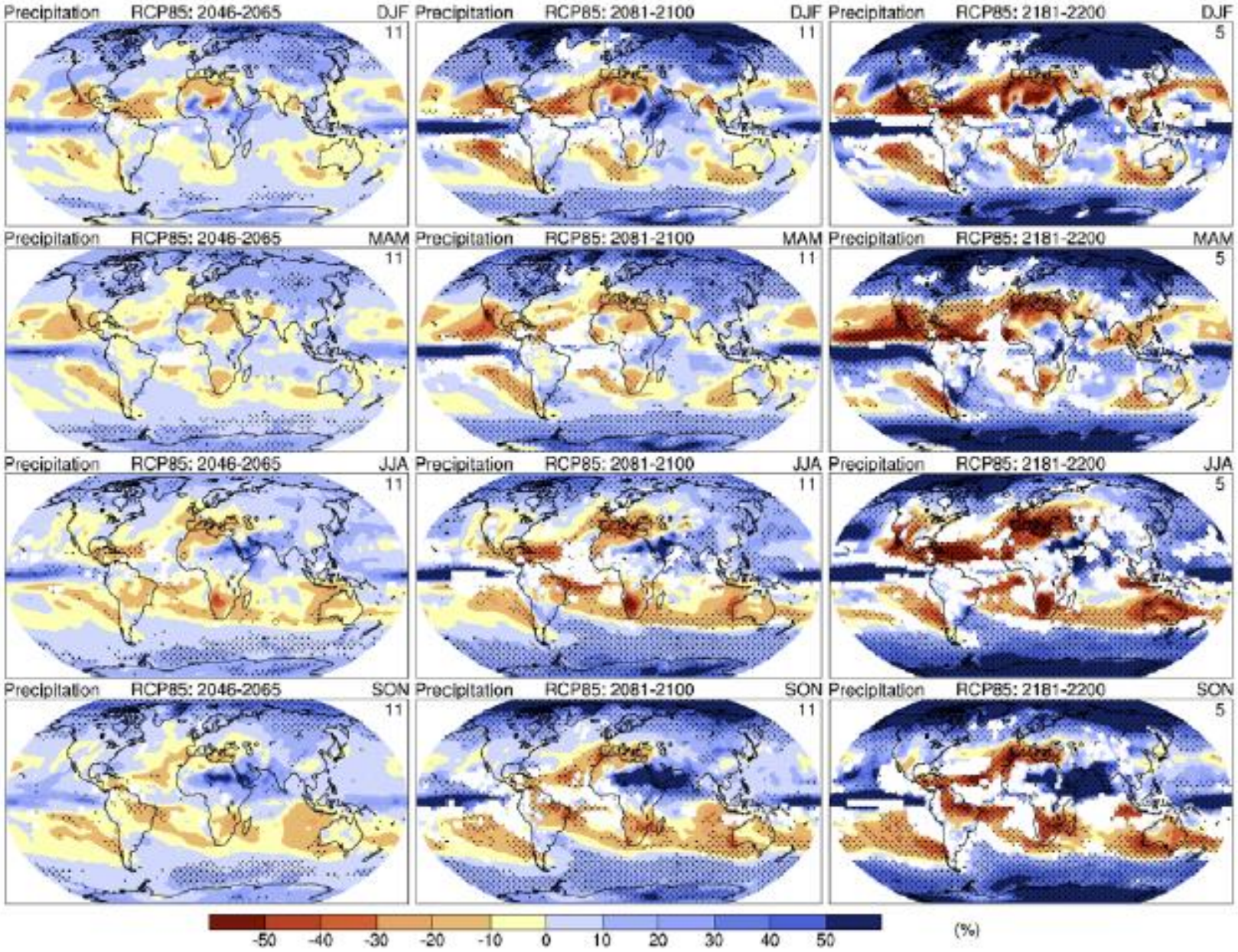


Precipitation Change



- What about higher resolution information about climate change?
- Global models run at about 150 km (80 mile) spatial resolution - what resolution do we need for adaptation purposes
- How to balance the desire for higher resolution with the other major uncertainties (future emissions, general response of climate system, internal variability).

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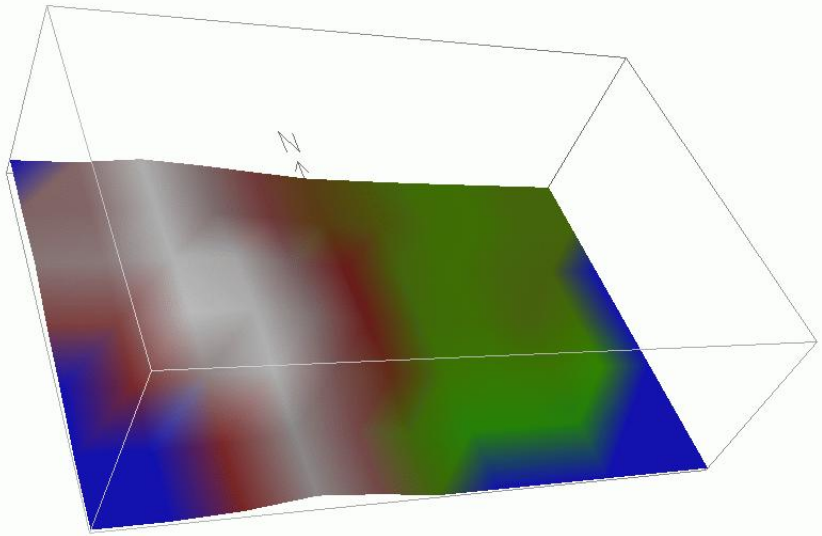
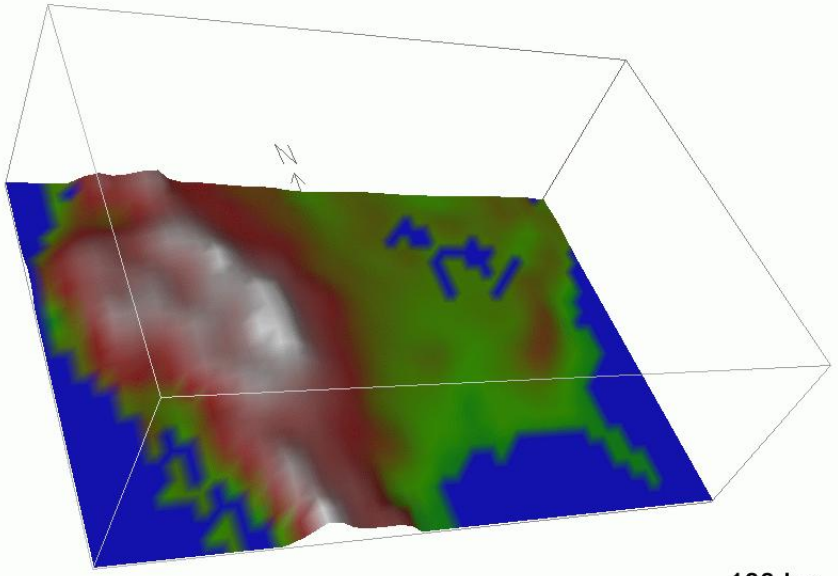
Uncertainty due to Spatial Scale of Regional Climate Simulations

Dynamical Downscaling

Global Climate Models



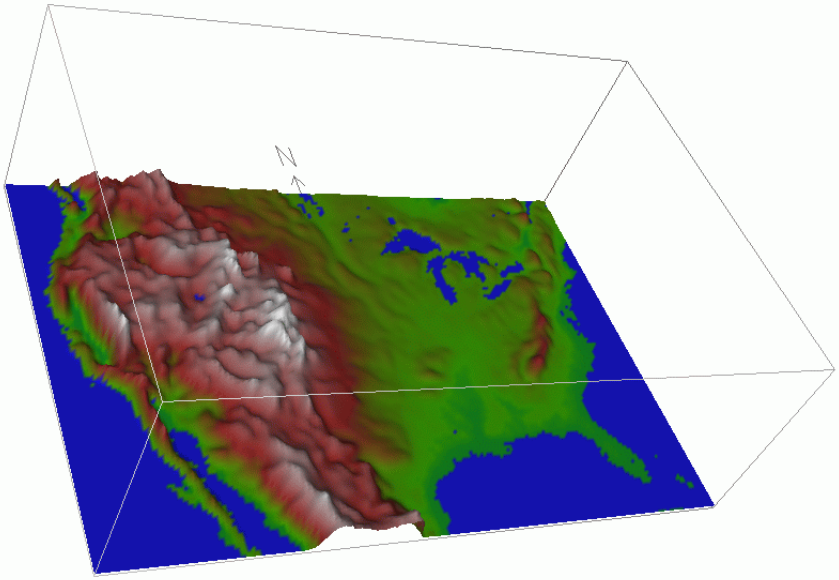
400 km



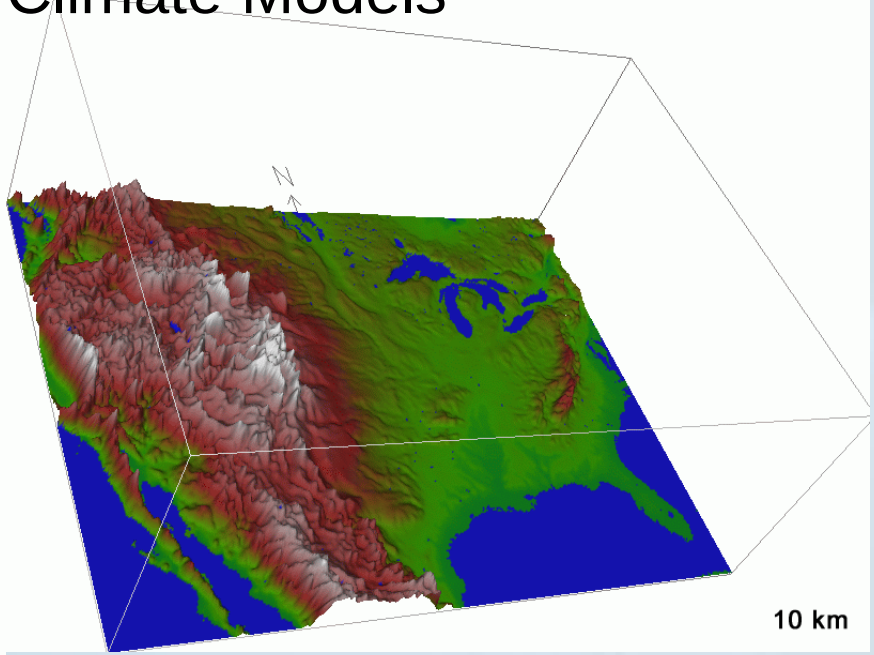
100 km

AR

Regional Climate Models



25 km



10 km

Objectives of Downscaling

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- Bridge mismatch of spatial scale between that of global climate models and the resolution needed for impacts and adaptation assessments
- Resolve high resolution processes that are responsible for regional climate

Different objectives may require different types of downscaling

But, once we have more regional detail, what difference does it make in any given impacts/adaptation assessment?

What is the added value?

Do we have more confidence in the more detailed results?

What high resolution climate modeling is really useful for

In certain specific contexts, provides insights on realistic climate response to high resolution forcing (e.g. mountains)

Regional Modeling Strategy

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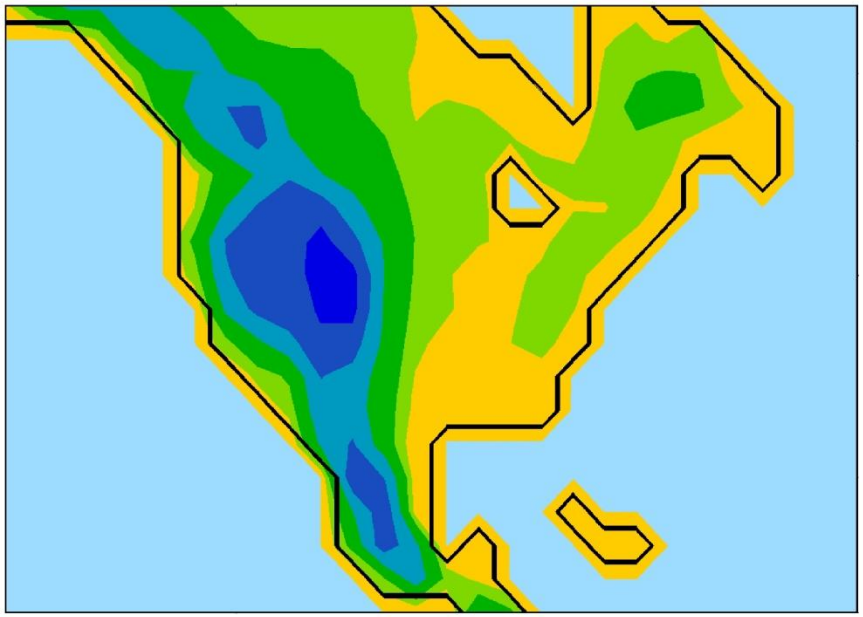
Nested regional modeling technique

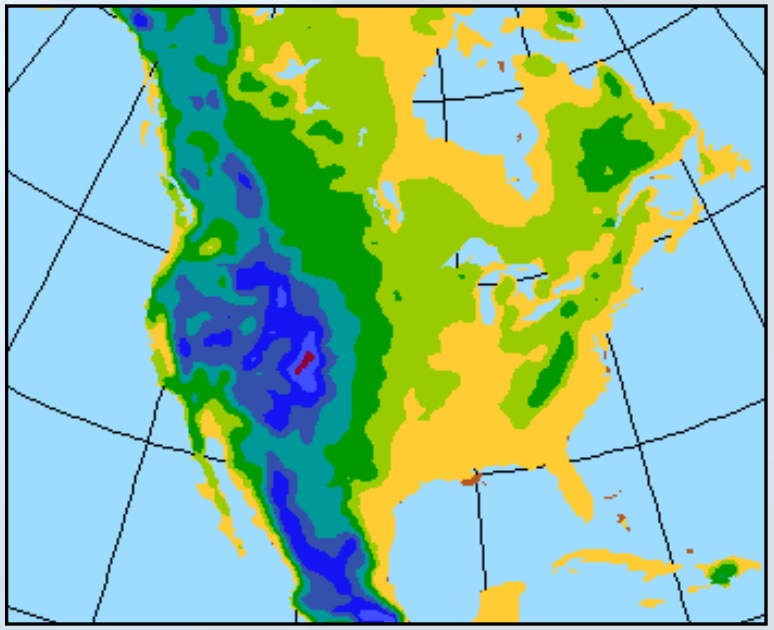
- Global model provides:
  - initial conditions – soil moisture, sea surface temperatures, sea ice
  - lateral meteorological conditions (temperature, pressure, humidity) every 6-8 hours.
  - Large scale response to forcing (100s kms)
- Regional model provides finer scale (10s km) response

Advantages of higher resolution



North America at typical global climate model resolution

Hadley Centre AOGCM (HadCM3), 2.5˚ (lat) x 3.75˚ (lon), ~ 280 km



North America at 50 km grid spacing

Uncertainties Contributed by Regional Climate Models

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- Not just the resolution, but often are different models (physics, dynamics of GCM are not the same as RCM)
- Size and location of the domain of interest
- Effect of the quality of lateral boundary conditions (e.g., from GCM)
- Also different realizations will produce different climate simulations (using different realization of GCM, and then different initial conditions for RCM)

The North American Regional Climate Change Assessment Program (NARCCAP)

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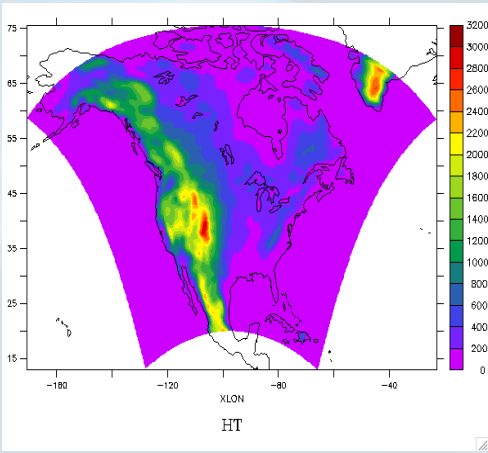
www.narccap.ucar.edu

- Explores multiple uncertainties in regional and global climate model projections
  - 4 global climate models x 6 regional climate models



- Develops multiple high resolution (50 km) regional climate scenarios for use in impacts and adaptation assessments

- Evaluates regional model performance to establish credibility of individual simulations for the future

- Participants: Iowa State, PNNL, LLNL, UC Santa Cruz, Scripps, Ouranos (Canada), UK Hadley Centre, NCAR

- Initiated in 2006, funded by NOAA-OGP, NSF, DOE, USEPA-ORD – 5-year program

NARCCAP Domain

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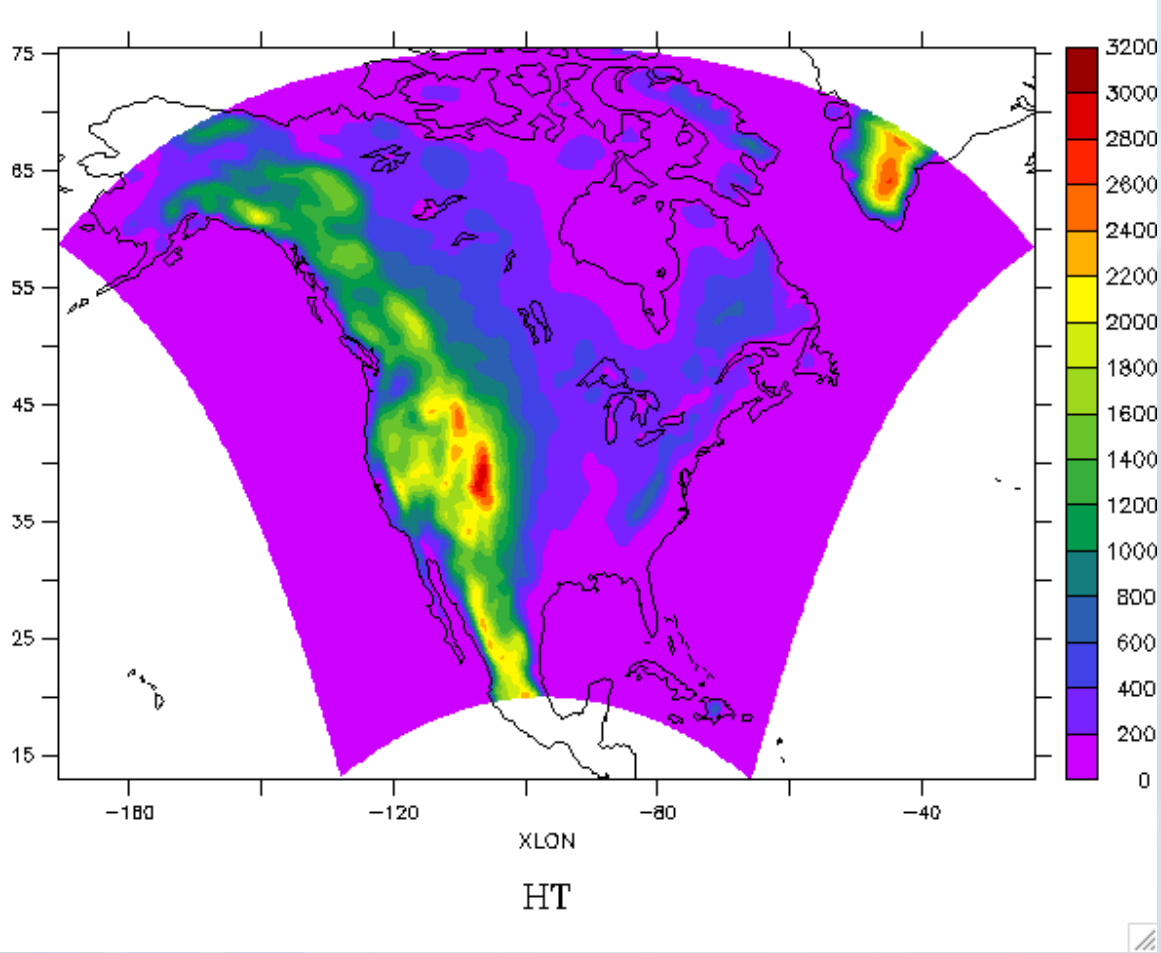

NARCCAP PLAN – Phase II

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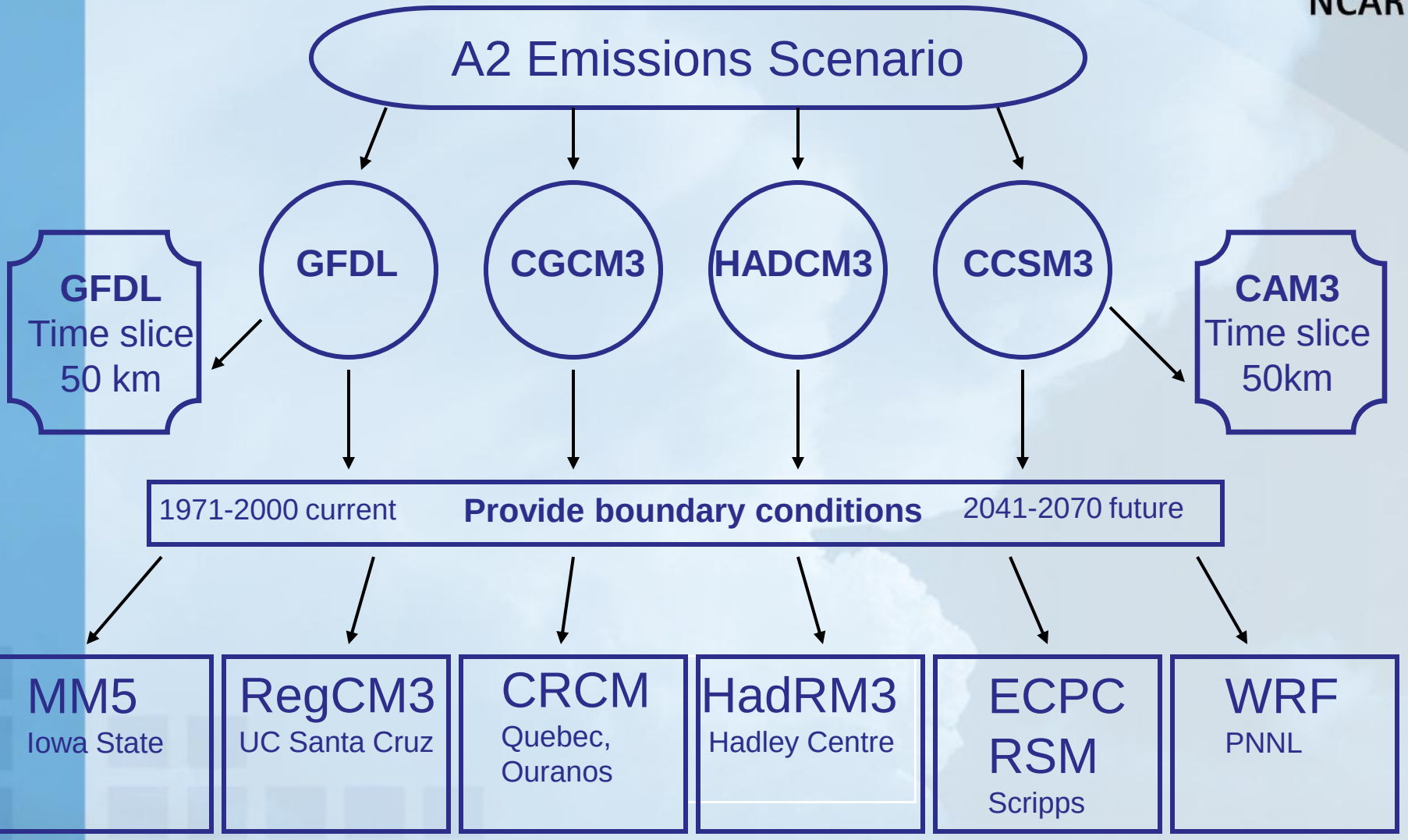

AOGCM-RCM Matrix

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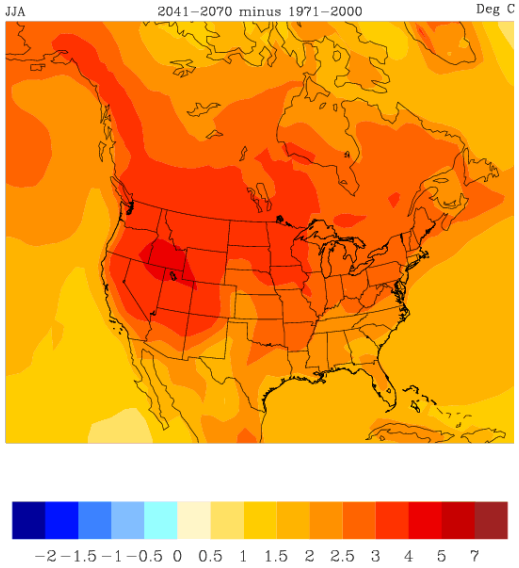
AOGCMS

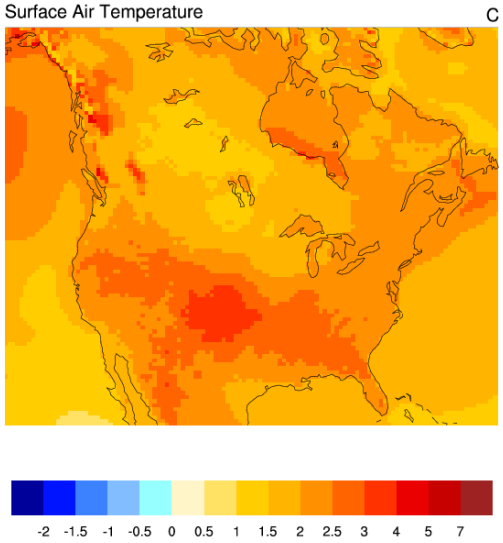
RCMs	GFDL	CGCM3	HADCM3	CCSM3
MM5			X*	X1**
RegCM	X1**	X**		
CRCM		X1**		X**
HadRM	X**		X1**	
RSM	X1**		X	
WRF		X**		X1**
*CAM3				X**
*GFDL	X**			

1 = chosen first GCM
*= time slice experiments
Red = run completed
** = data loaded

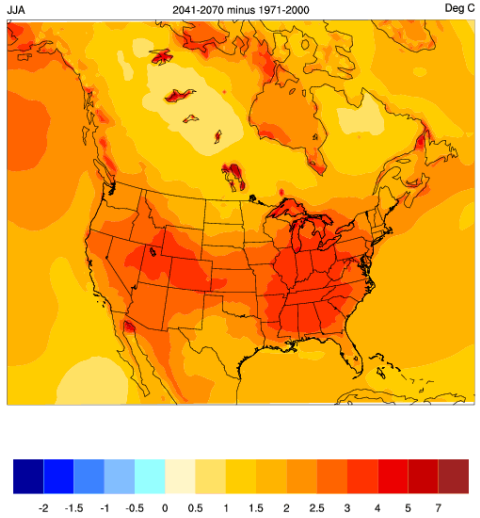
CCSM Change In Seasonal Avg Temp



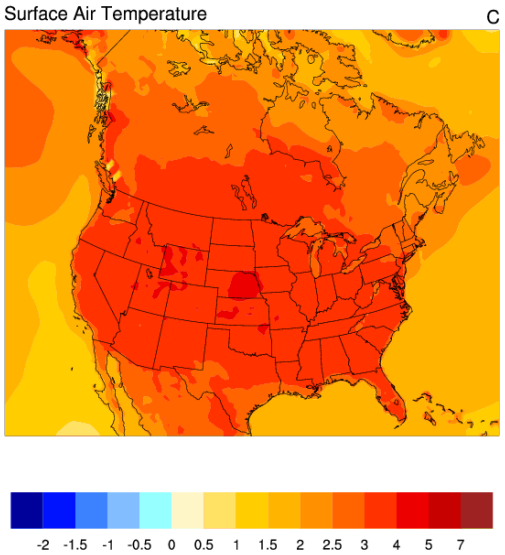
MM5I+CCSM Change in JJA Avg Temp



WRFG+ccsm Change In Seasonal Avg Temp



CRCM+CCSM Change in JJA Avg Temp



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CCSM-driven change in summer temperature

17 GCMs used in AR4 Change in Summer Precipitation

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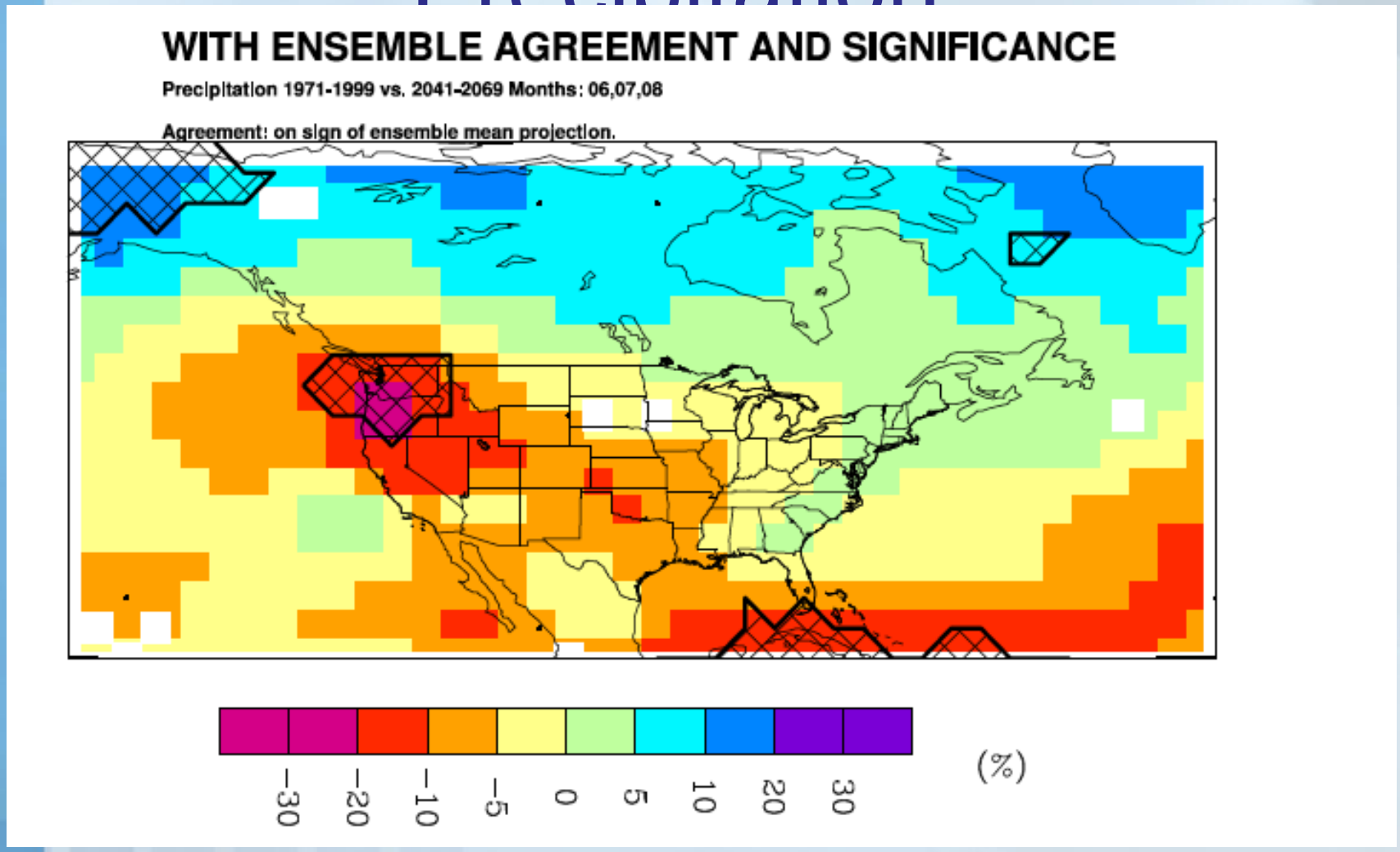

Mearns et al. PNAS (submitted)

4 GCMs used in NARCCAP

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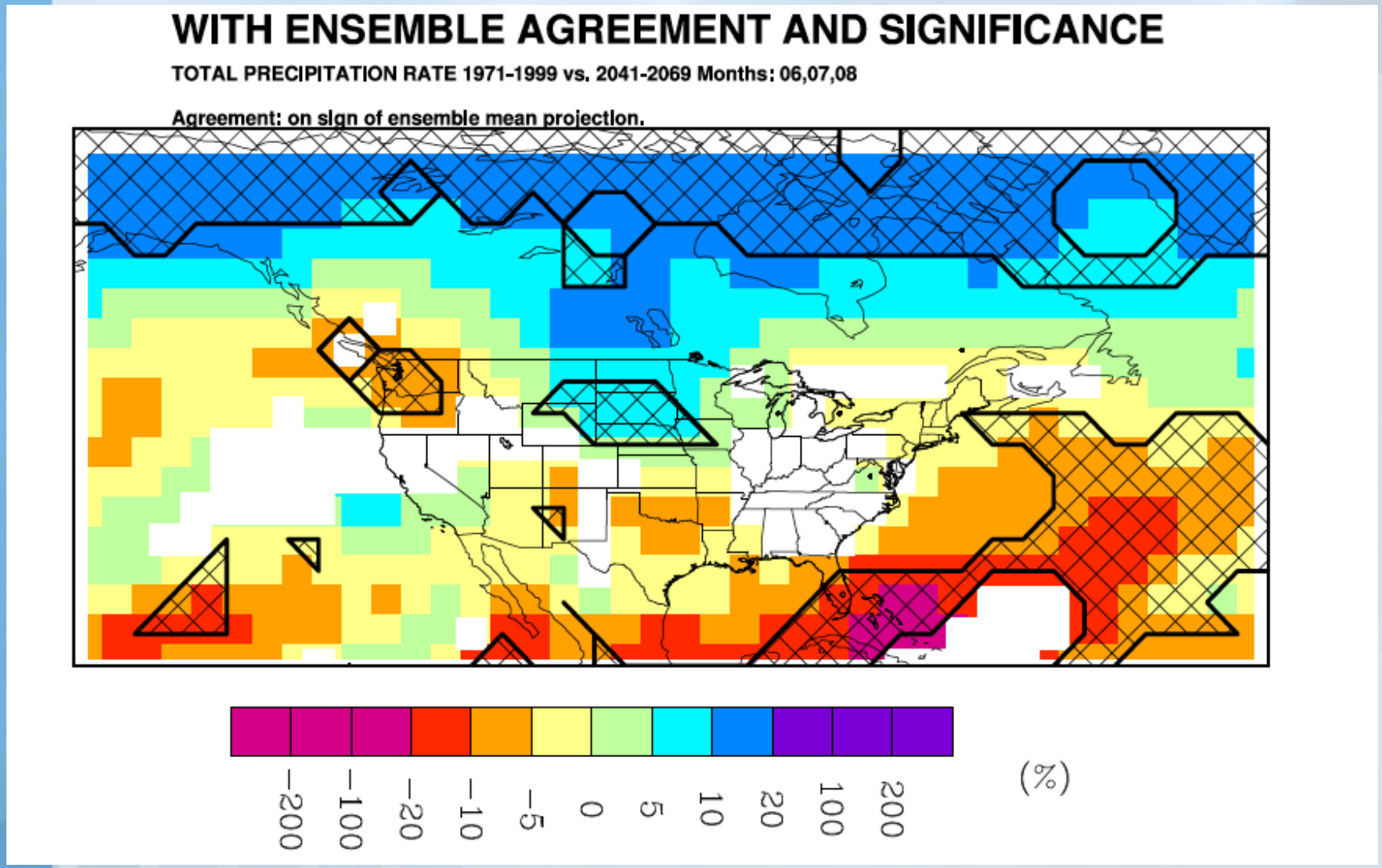

10 RCMs
Change in Summer Precipitation

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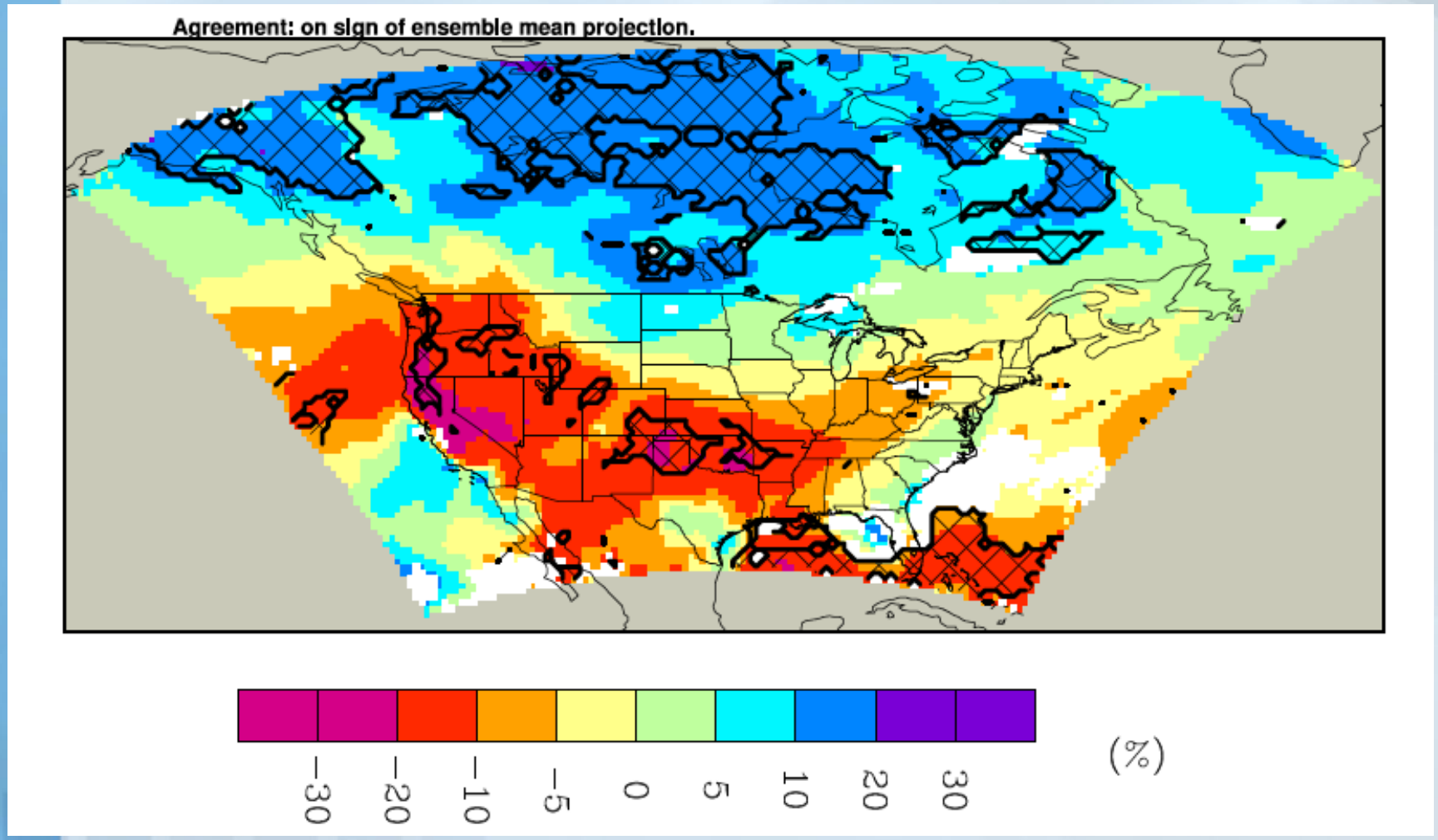

Bukovsky Regions

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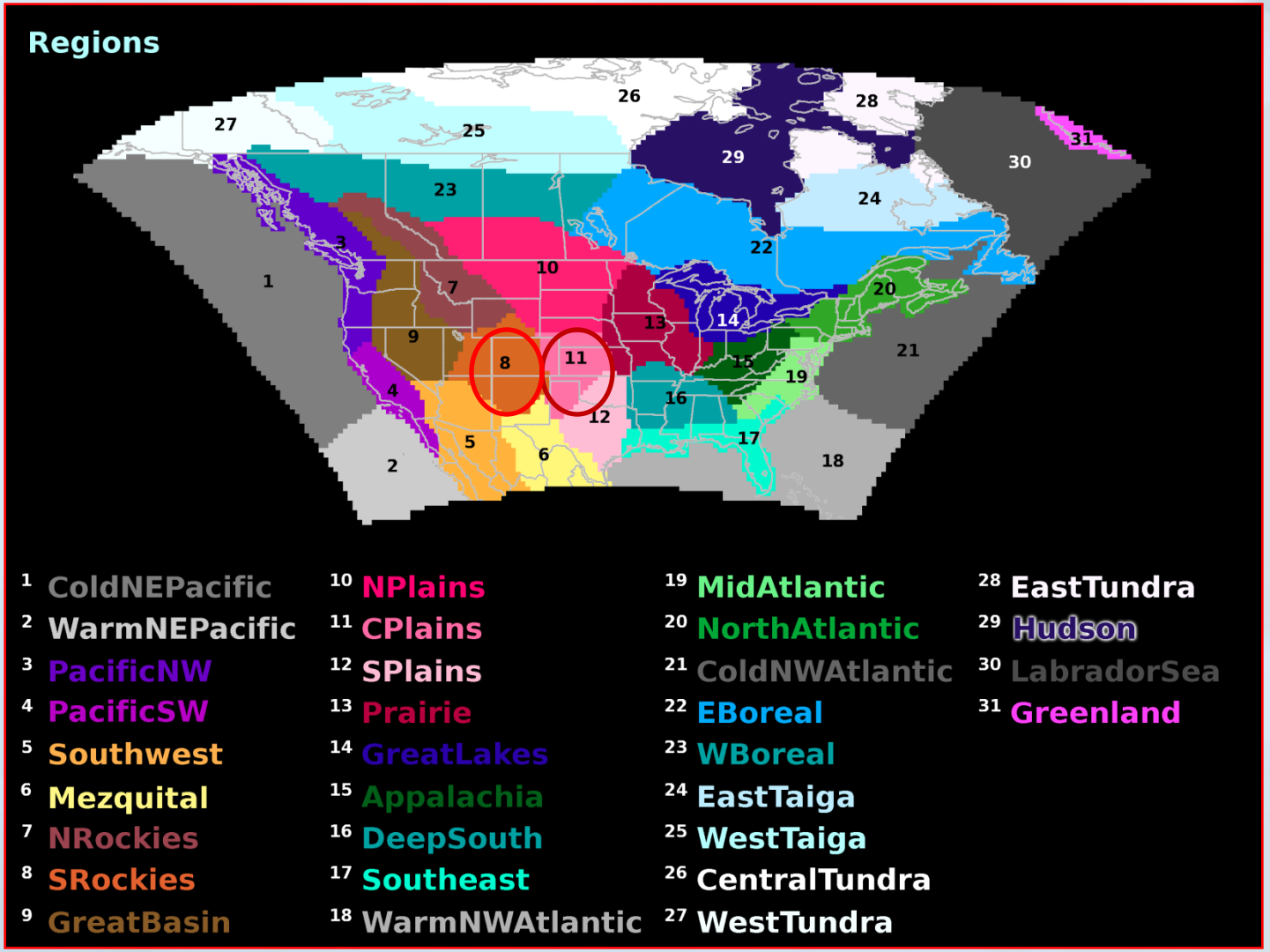
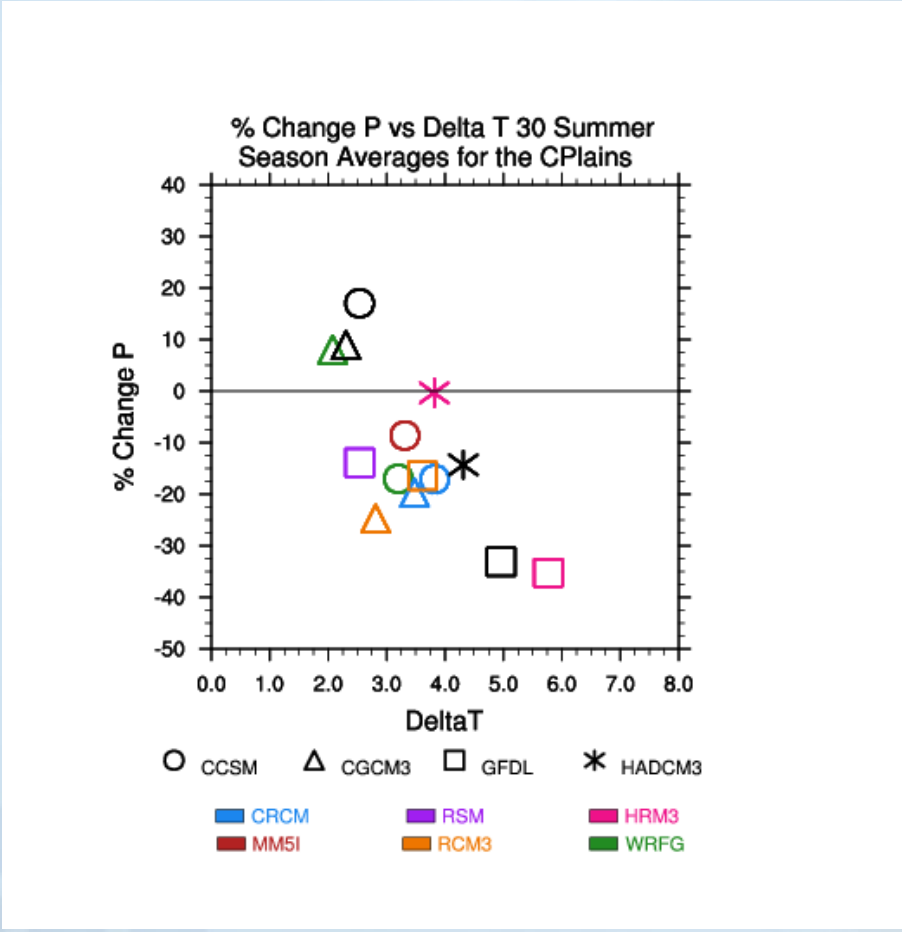
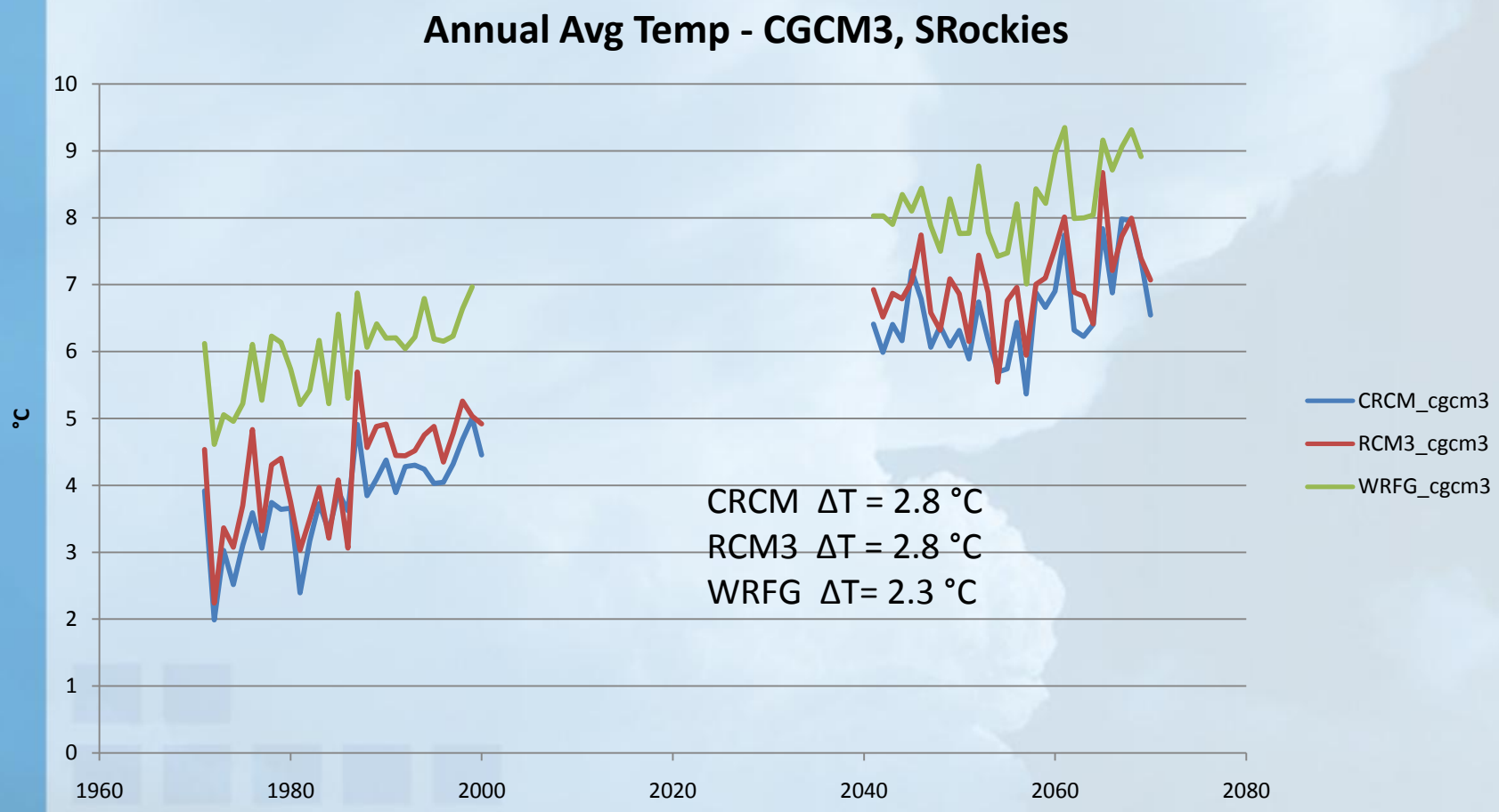


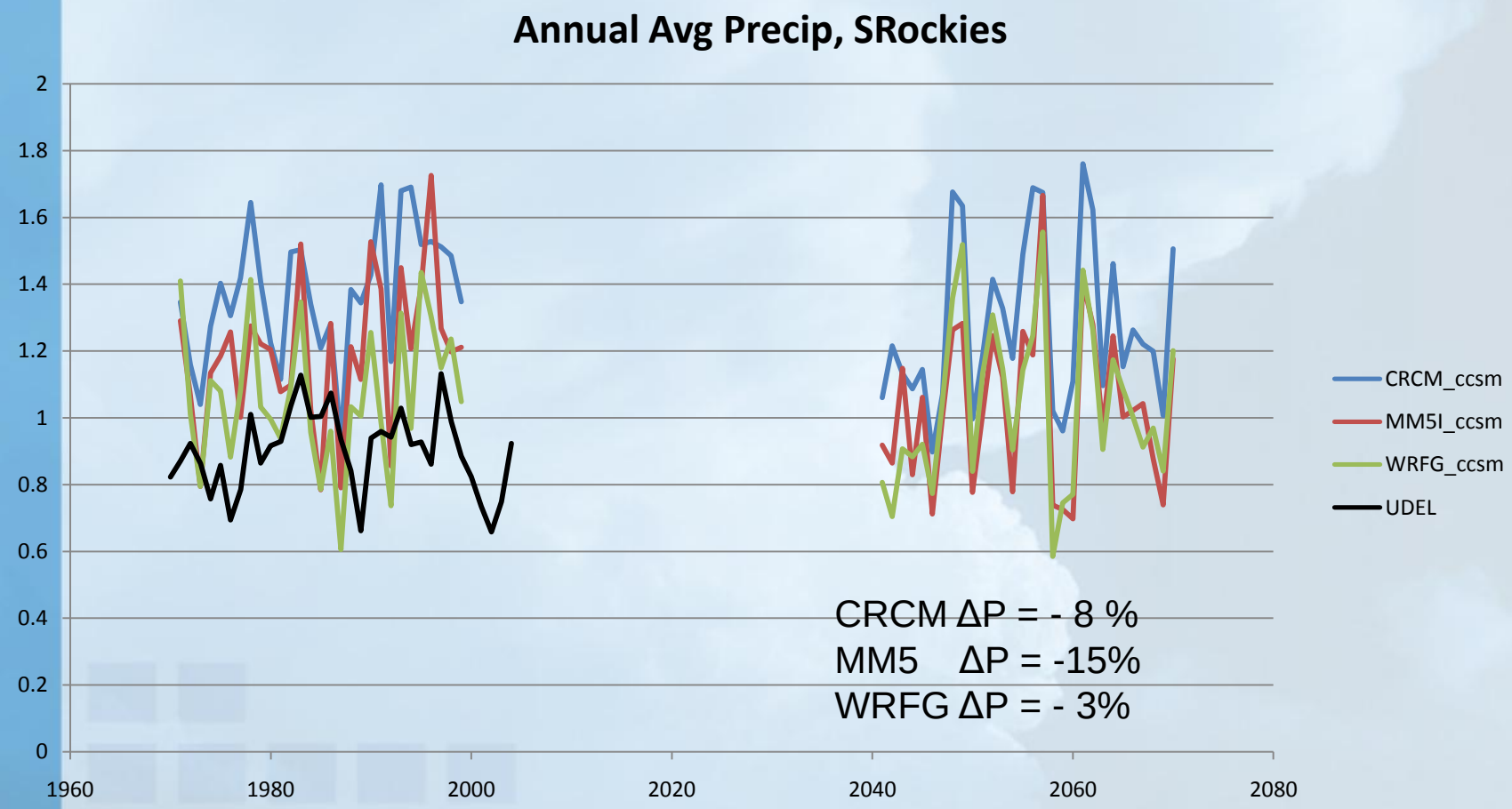
Central Plains Summer



South Rocky Mountain Region



Southern Rockies



Conclusions

- The RCMs tend to intensify patterns of change in precipitation (i.e., greater decreases in summer; greater increases in winter)
- RCMs are most dominant in summer in terms of producing information different from the global models.
- But more process level studies are necessary to determine if RCM changes are more credible than those of GCMs

Mother Of All Ensembles

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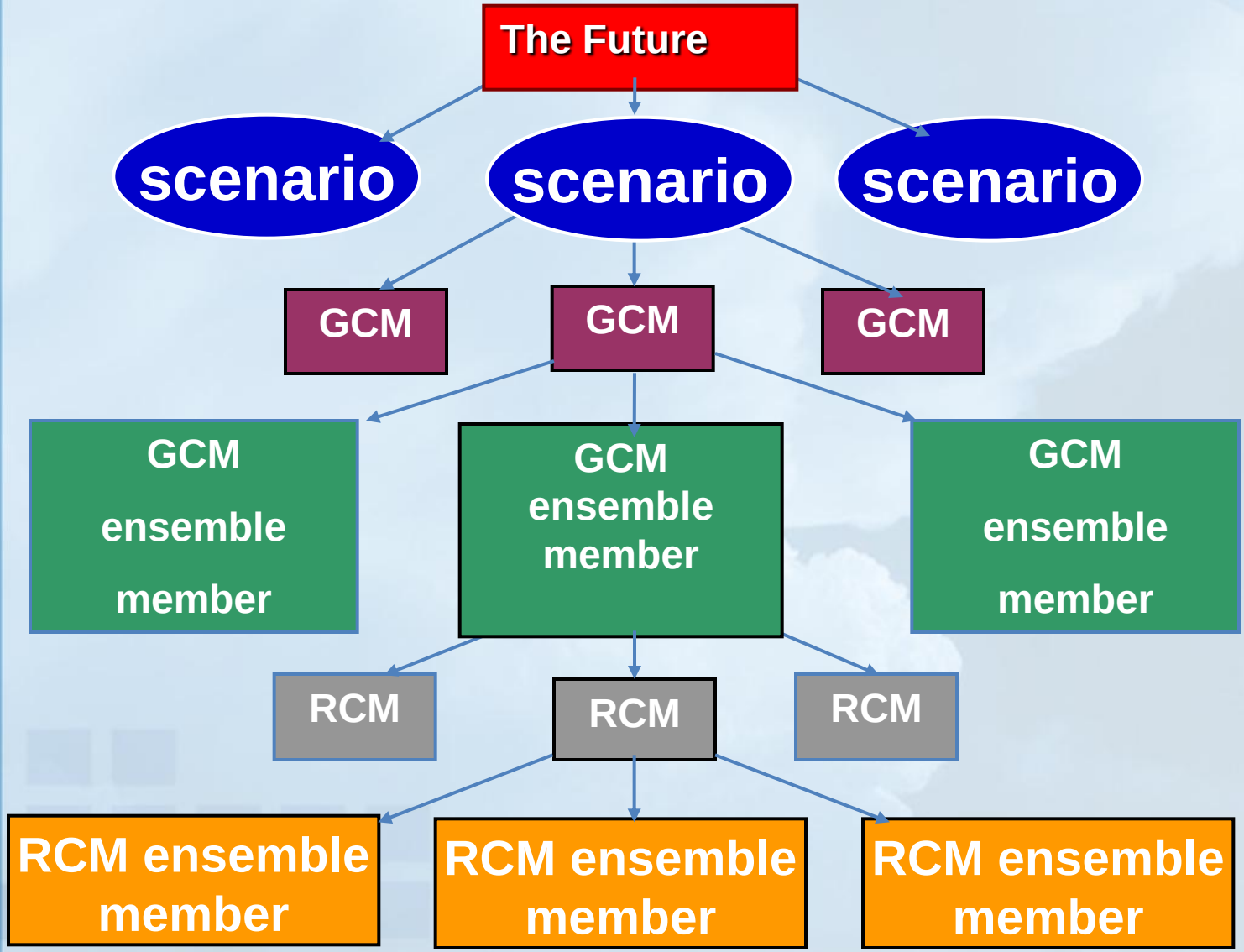
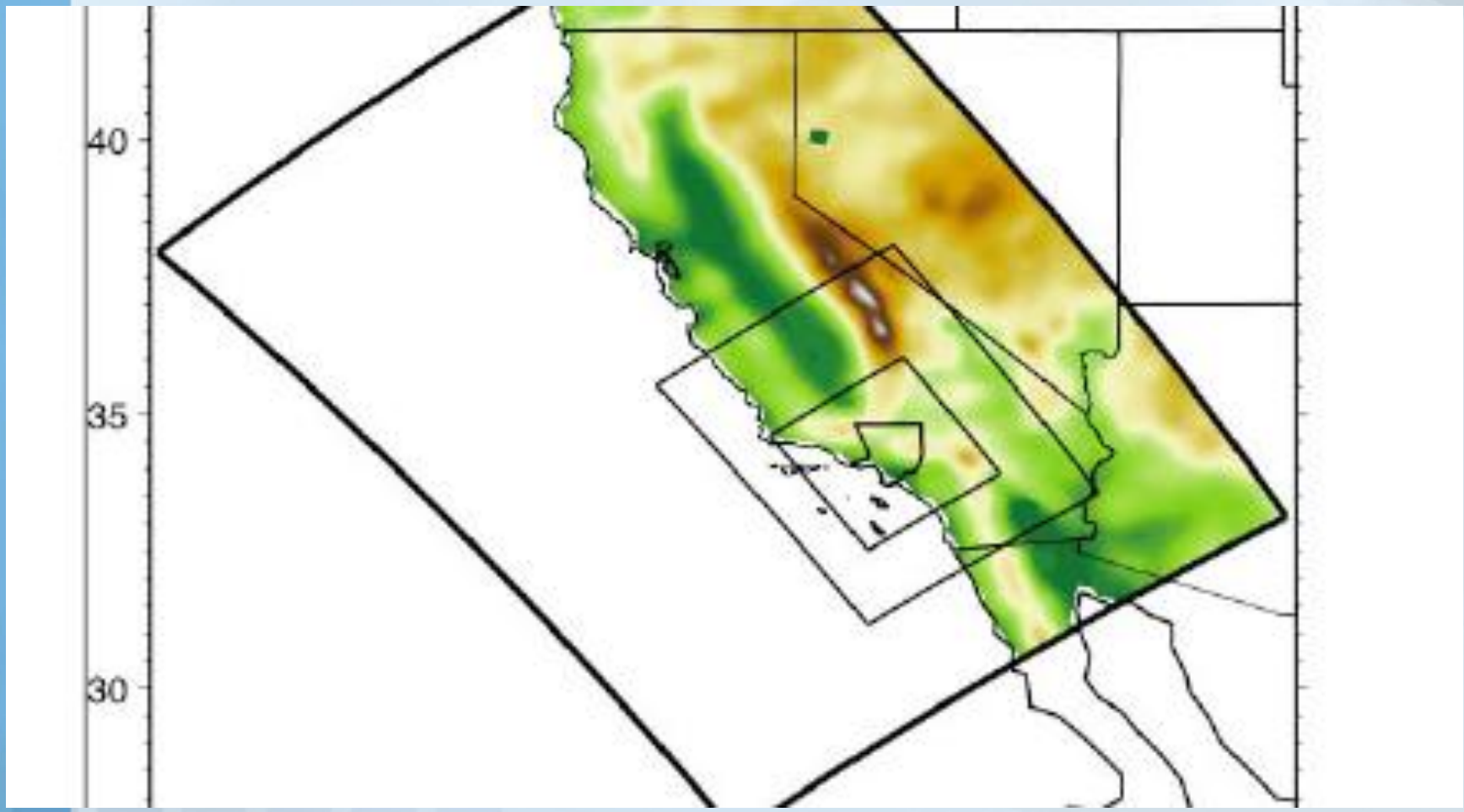


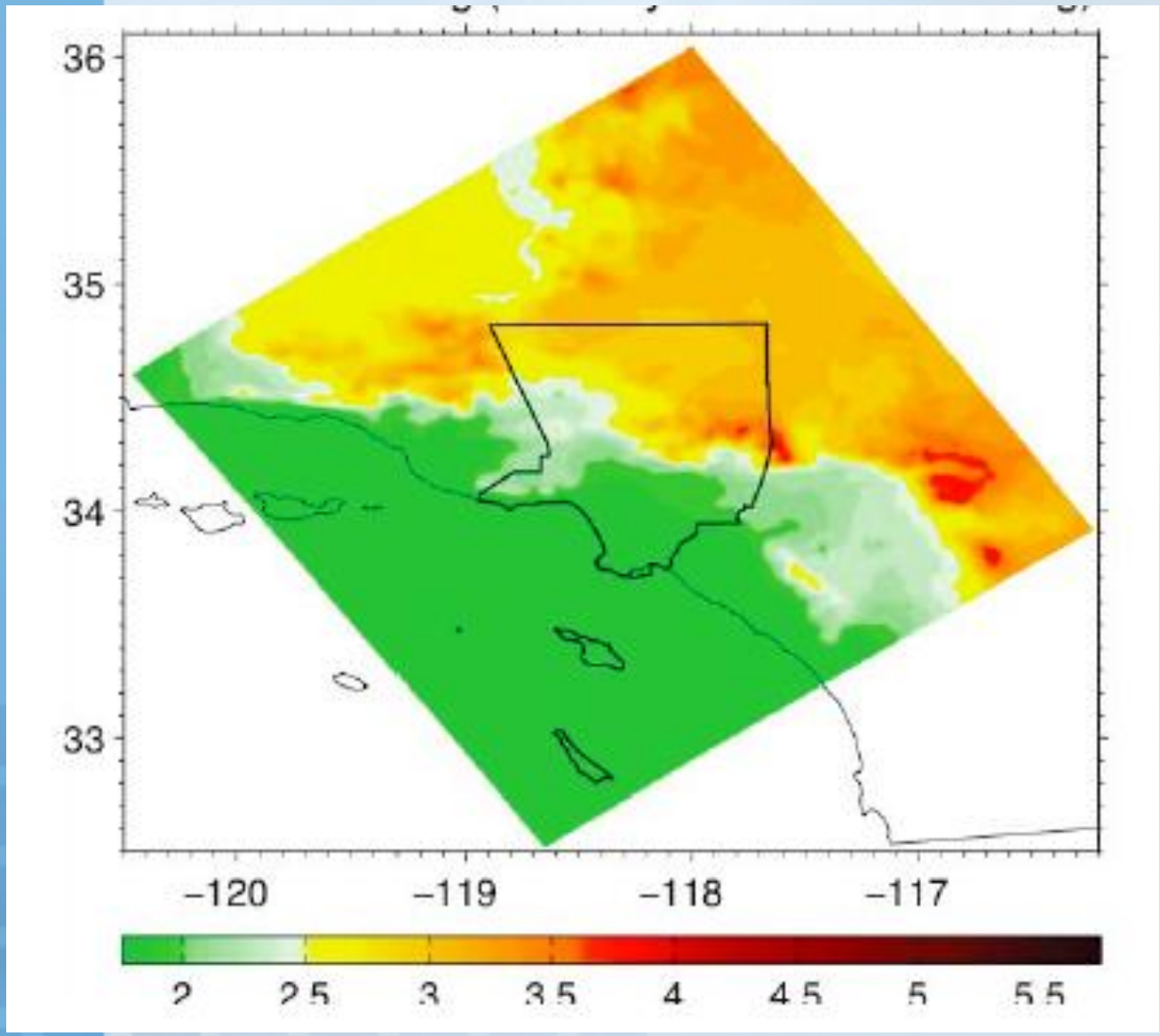
Going Higher and Higher

WRF Simulations – So Cal



Hall et al., 2012 Nests 18, 6, 2 kms

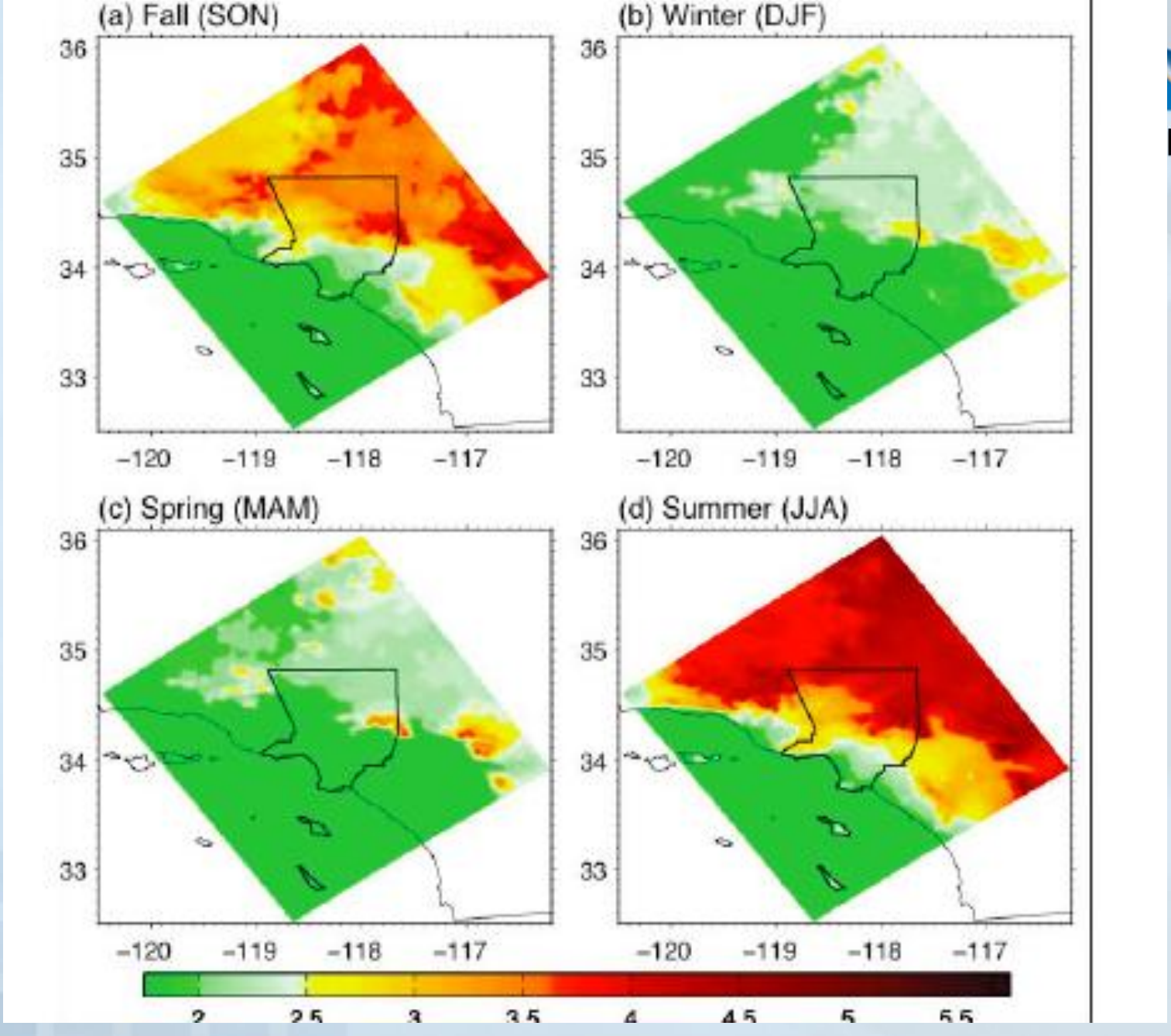
Annual Temperature Change



Current = NARR 1981-2000

Future = RCP 8.5 CCSM4 2041-60 (NARR baseline perturbed with CC signal from CCSM4)

Degrees F


(a) Fall (SON)
(b) Winter (DJF)
(c) Spring (MAM)
(d) Summer (JJA)
36
35
34
33
−120
−119
−118
−117
2
2.5
3
3.5
4
4.5
5
5.5

Degrees F

And What of Added Value?

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- Do we agree on what it is?
- Do we agree on how to demonstrate it?
- Usually demonstrated through better validation at high resolution – may be necessary but not sufficient conditions
- Hall et al. does demonstrate added value

Dueling Perspectives

- ‘Adapting to climate change … will require accurate and reliable predictions of changes in regional weather systems, especially extremes.’

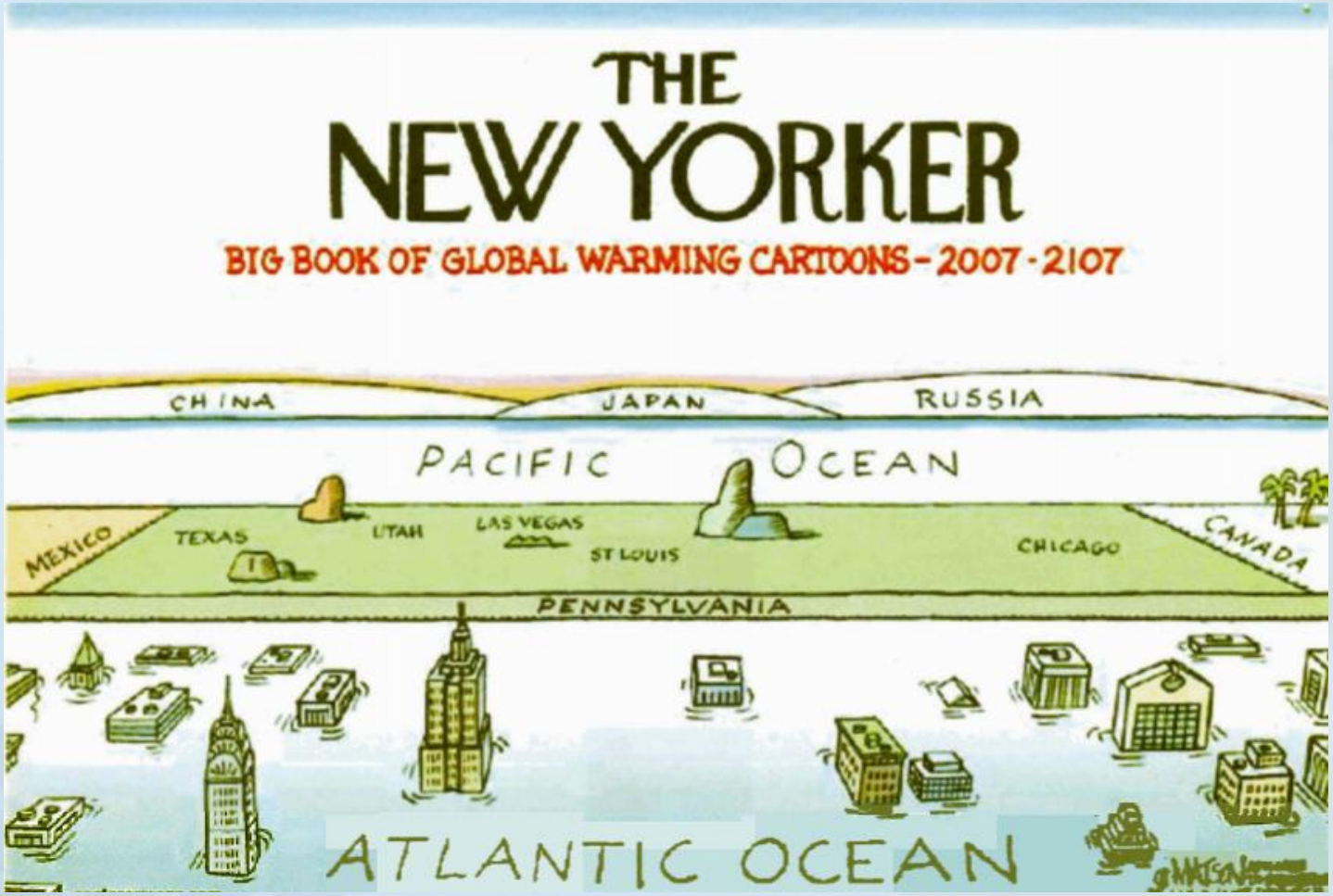
  – Nature editorial, 2008 and Shukla et al., 2009

  World Modeling Summit for Climate Prediction

- ‘Effective and robust adaptation strategies are not significantly limited by lack of accurate and precise regional climate predictions.’

  - Hulme and Dessai, 2008

The End


THE
NEW YORKER
BIG BOOK OF GLOBAL WARMING CARTOONS - 2007 - 2107
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CHICAGO
CANADA
PENNSYLVANIA
ATLANTIC OCEAN

Stat downscaling method
Hall et al., 2012