The North American Regional Climate Change Assessment Program (NARCCAP)

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NARCCAP Participants

- Raymond Arritt, David Flory, William Gutowski, Gene Takle, Iowa State University, USA
- Richard Jones, Erasmo Buono, W. Moufouma-Okia, Hadley Centre, UK
- Daniel Caya, Sébastien Biner, OURANOS, Canada
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- Isaac Held, NOAA Geophysical Fluid Dynamics Laboratory, USA
- René Laprise, Univ. de Québec à Montréal, Canada
- Ruby Leung, J. Correia, Y. Qian, Pacific Northwest National Laboratories, USA
- Linda Mearns, Seth McGinnis, Don Middleton, Doug Nychka National Center for Atmospheric Research, USA
- Ana Nunes, John Roads†, Scripps Institution of Oceanography, USA
- Steve Sain, Univ. of Colorado at Denver, USA
- Lisa Sloan, Mark Snyder, Univ. of California at Santa Cruz, USA

Coordinated projects give added value through:

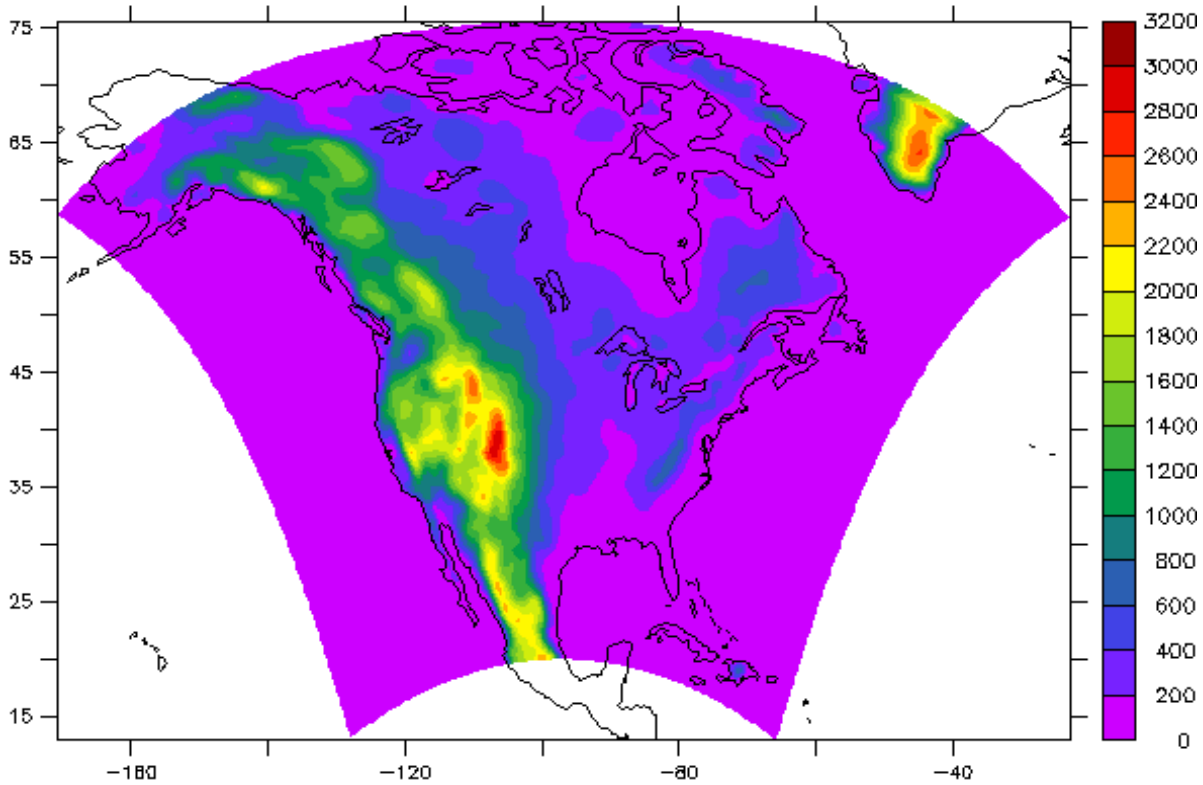
- Cooperation
  - assembling initial and boundary conditions, error checking, data archiving, software development, etc.
- Creating multi-model ensembles
- Comparing model skill in a controlled way
  - same boundary data, domain, and other specifications
  - comparisons can lead to model improvements
- Using a consistent output format that makes it easier to use the results for analysis and applications.

North American Regional Climate Change Assessment Program (NARCCAP)

- Assess regional climate change for North America by downscaling 4 AOGCMs with 6 RCMs.
  - Each RCM downscales two AOGCMs
  - Standard output format similar to AR4/CMIP3.

- Project phases and status:
  - Phase I: RCMs driven by reanalysis (1979-2004) to examine uncertainty in RCMs (completed)
  - Phase IIa: RCMs driven by AOGCM output for 20th century (1971-2000) (nearing completion)
  - Phase IIb: RCMs driven by AOGCM output from SRES A2 scenario (2041-2070) (nearing completion)

NARCCAP Domain

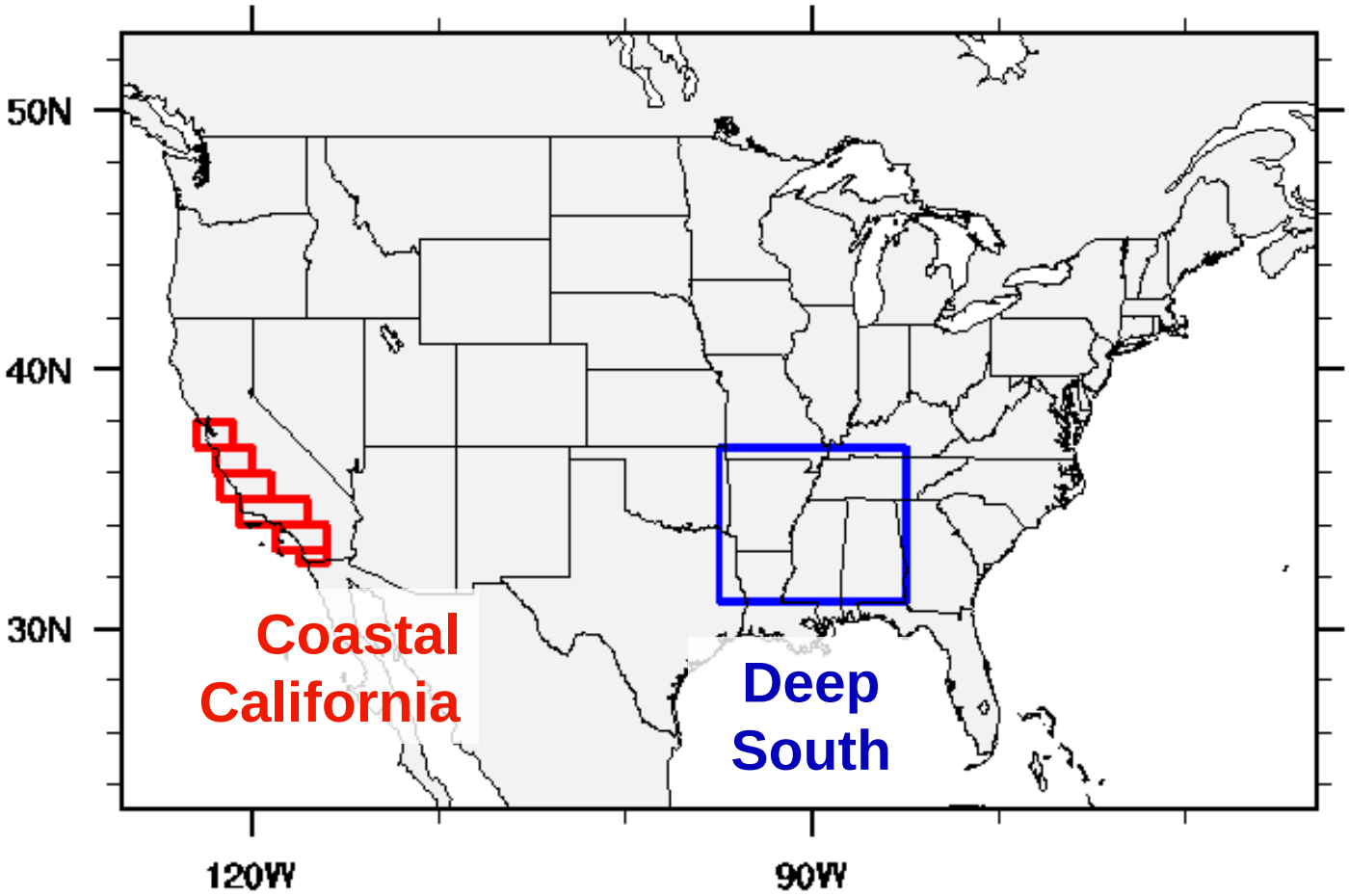


There are minor differences amongst models due to use of different grid projections.

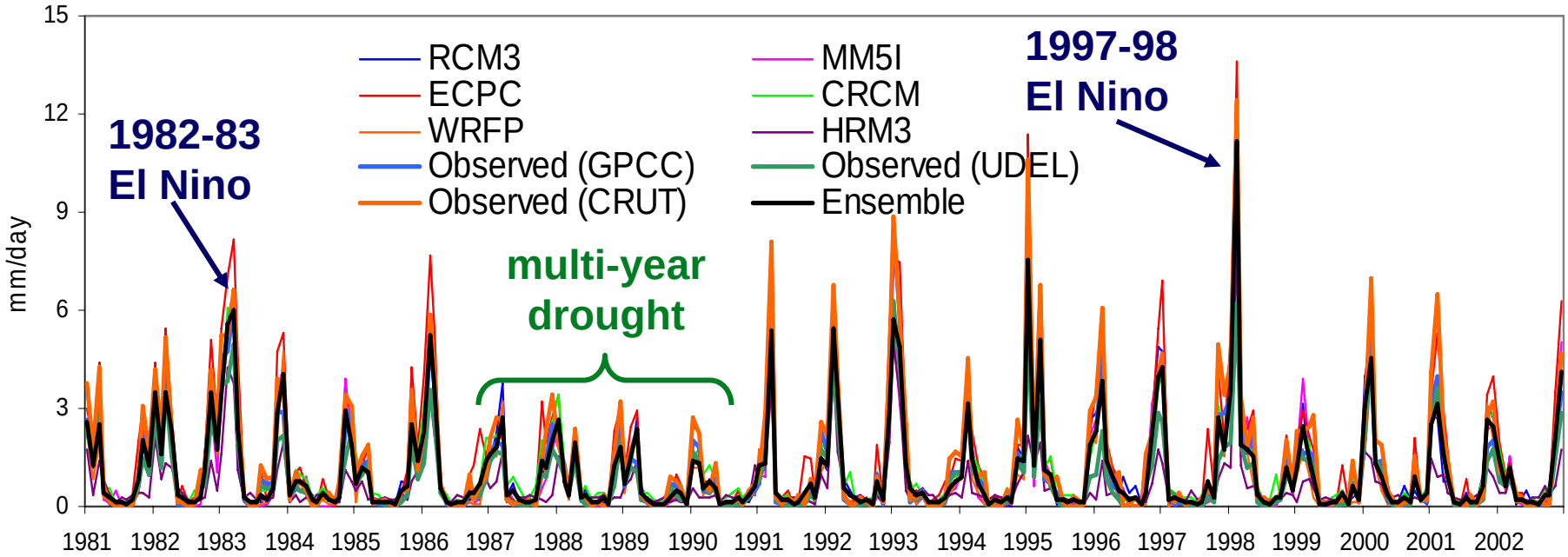
Phase I: Reanalysis-driven runs

- All 6 RCMs have completed the reanalysis-driven runs.
- Results are shown for 1981-2002.
  - We compare with three 0.5^{o} gridded precipitation analyses: University of Delaware (shown here), GPCC, CRU
- Configuration:
  - RCM horizontal grid spacing 50 km
  - boundary data from NCEP/DOE Reanalysis 2
  - boundaries, SST and sea ice updated every 6 hours

Precipitation analysis for two regions



Monthly time series of precipitation in coastal California



small spread, high skill

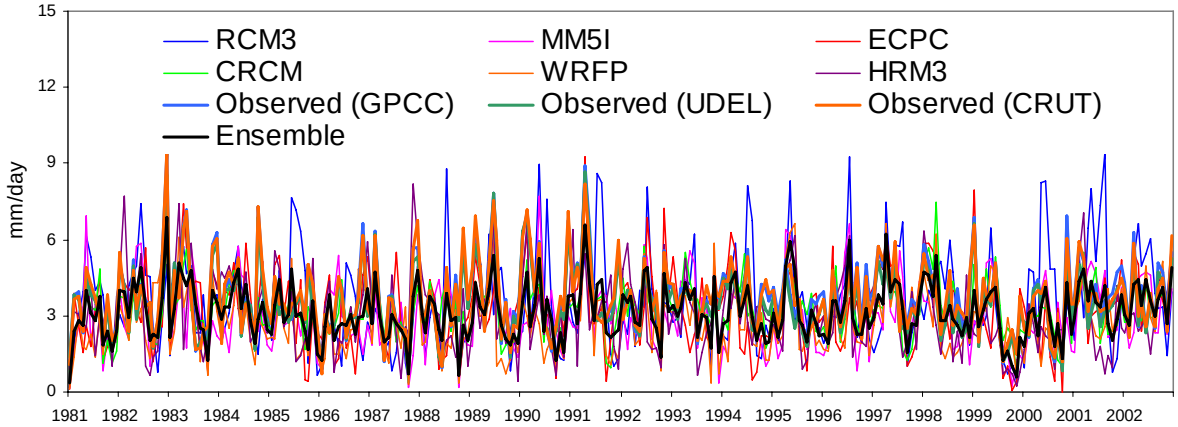
Correlation with Observed Precipitation - Coastal California

Model	Correlation
HadRM3	0.857
RegCM3	0.916
MM5	0.925
RSM	0.945
CRCM	0.946
WRF	0.918
Ensemble	**0.947**

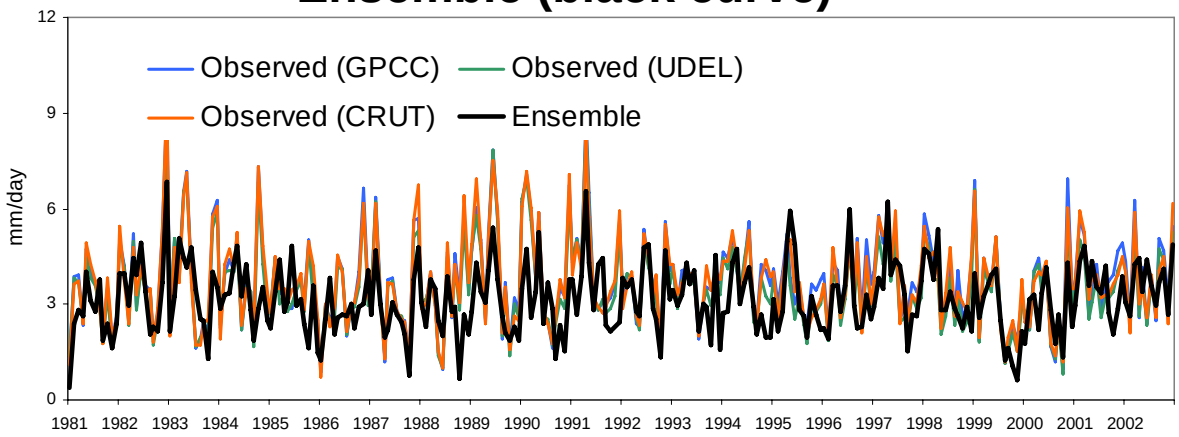
All models have high correlations with observed **monthly time series** of precipitation.

Ensemble mean has a higher correlation than any model

Monthly Time Series - Deep South



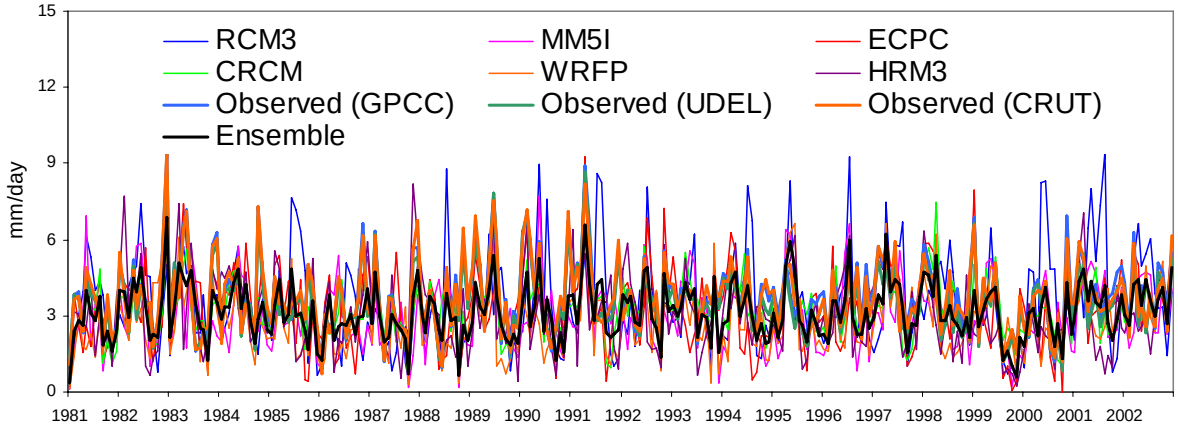
Ensemble (black curve)



Model	Correlation
HadRM3	0.489
RegCM3	0.231
MM5	0.343
RSM	0.649
CRCM	0.649
WRF	0.513
Ensemble	**0.640**

Two models (RSM and CRCM) perform much better. These models inform the domain interior about the large scale.

Monthly Time Series - Deep South



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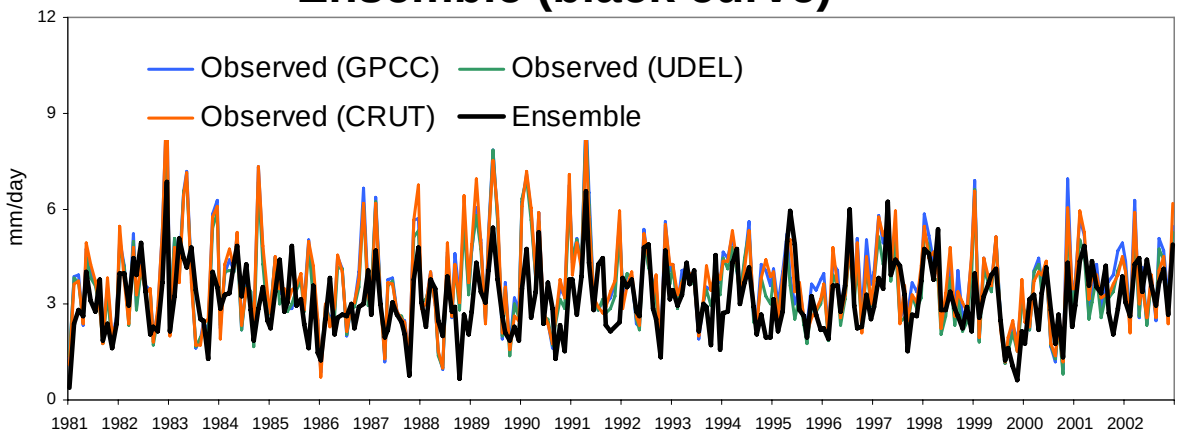

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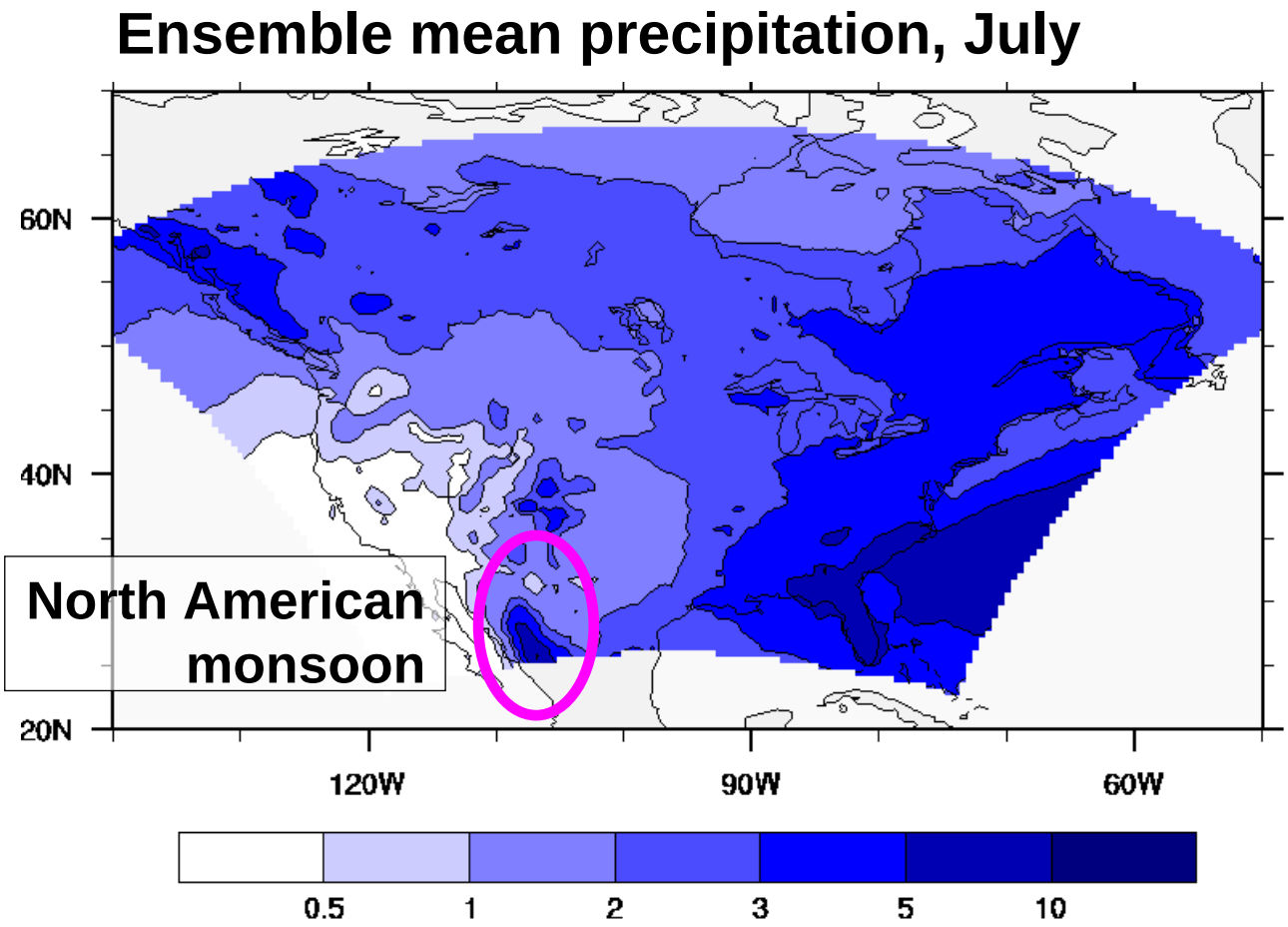
Ensemble	**0.640**
RSM+CRCM	**0.727**

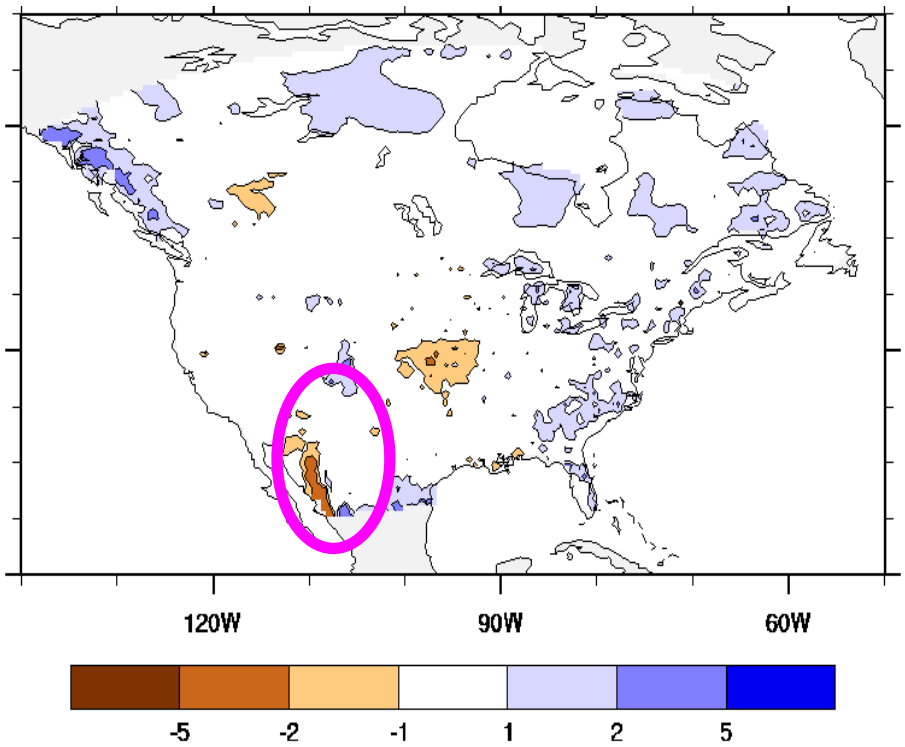
A “mini ensemble” of RSM and CRCM performs best in this region.

Process oriented evaluation: the North American monsoon

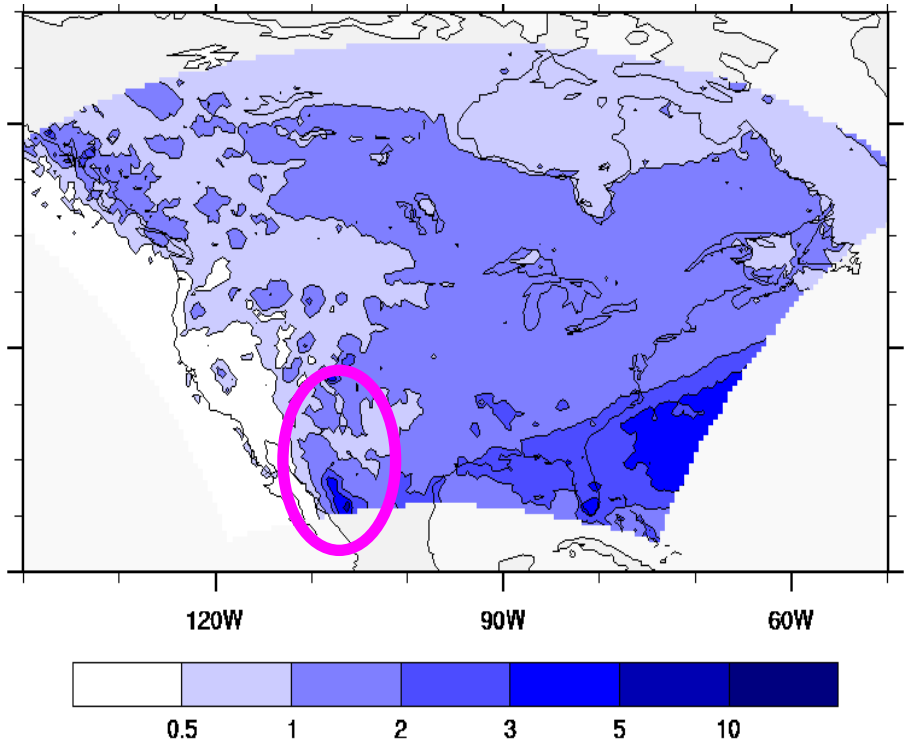


Ensemble error and spread (July)

Bias

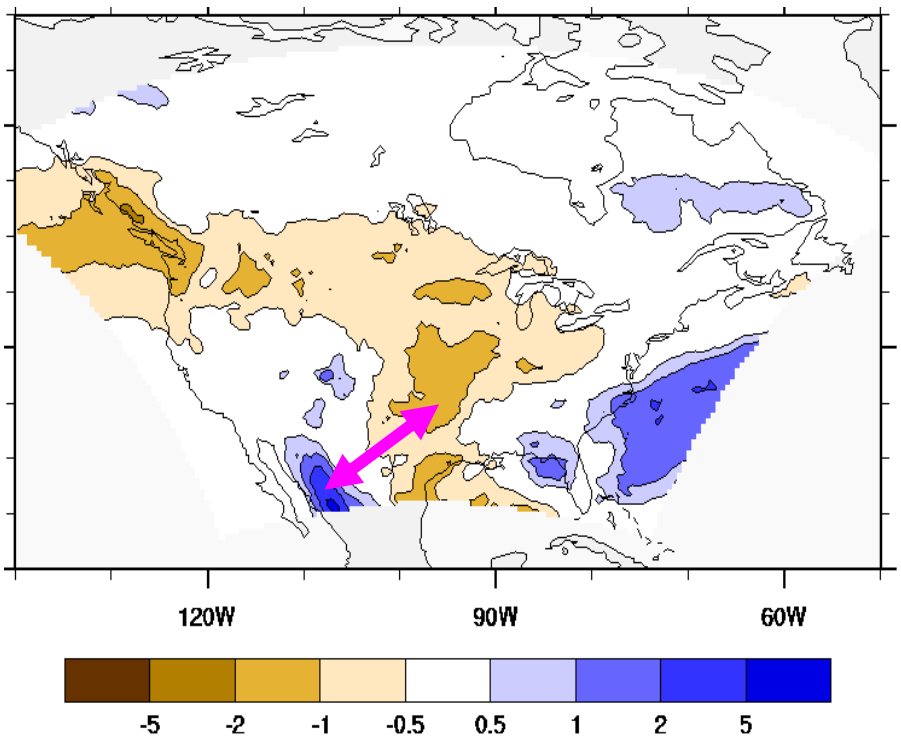


Ensemble spread

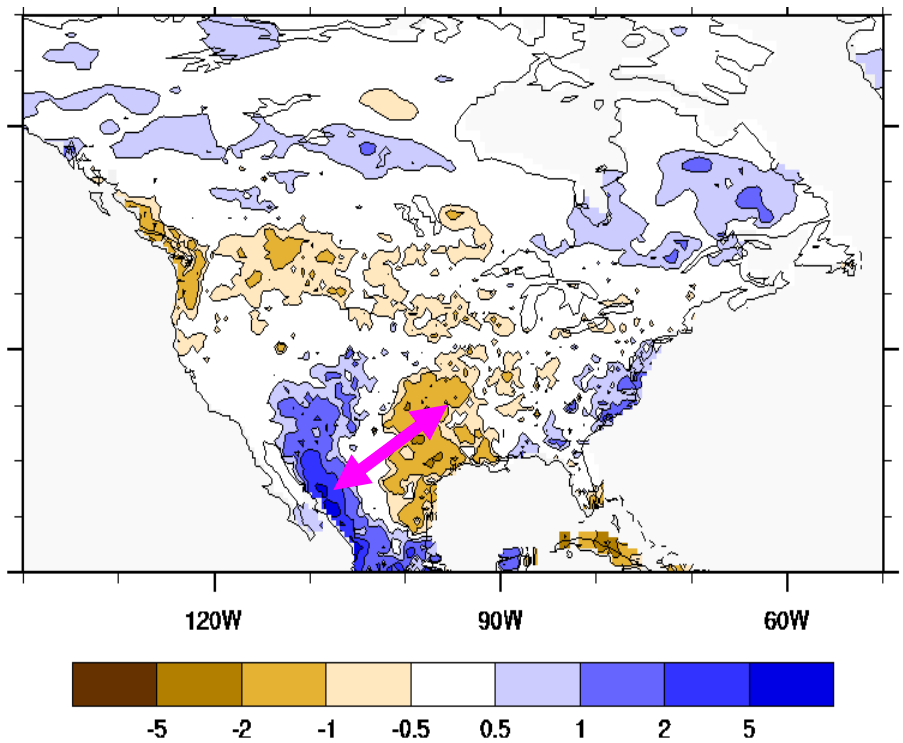


The ensemble reproduces the dipole of June-July precipitation change, but the monsoon does not extend as far north as observed.

ensemble July minus June



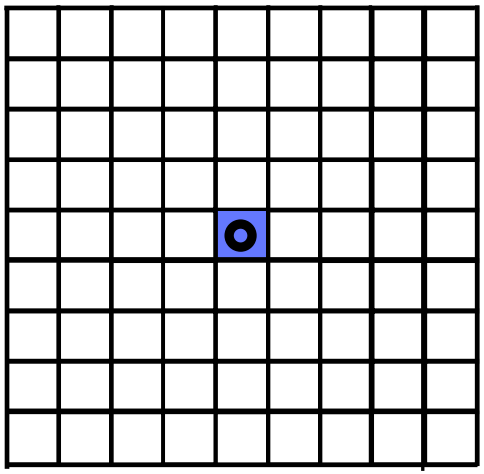
observed July minus June



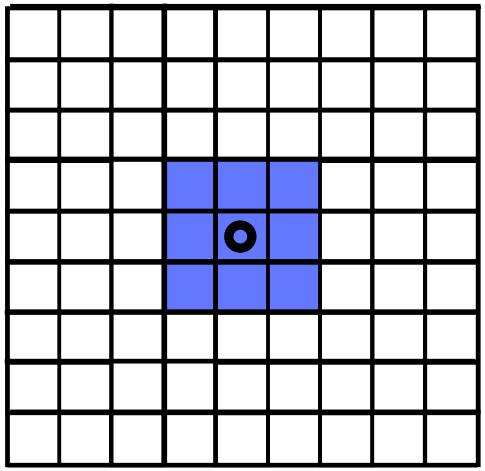
How does spatial aggregation affect prediction skill?

Average both model and observations onto 3x3 or 5x5 grid square areas.

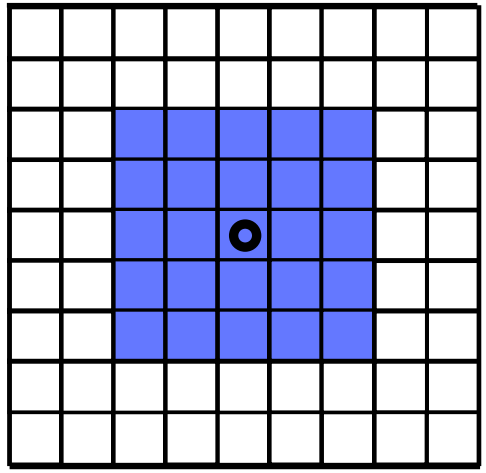
pointwise

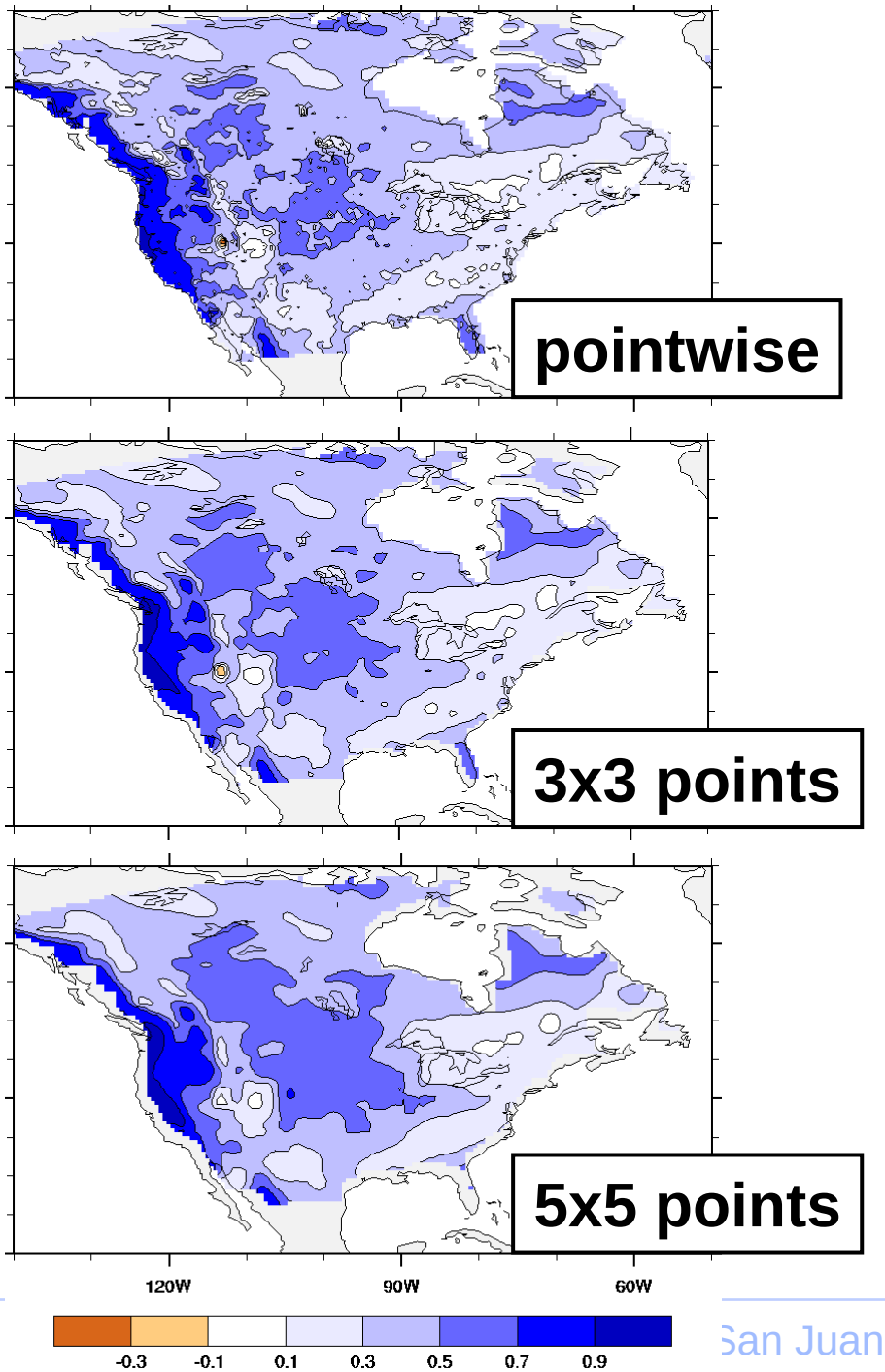


3x3



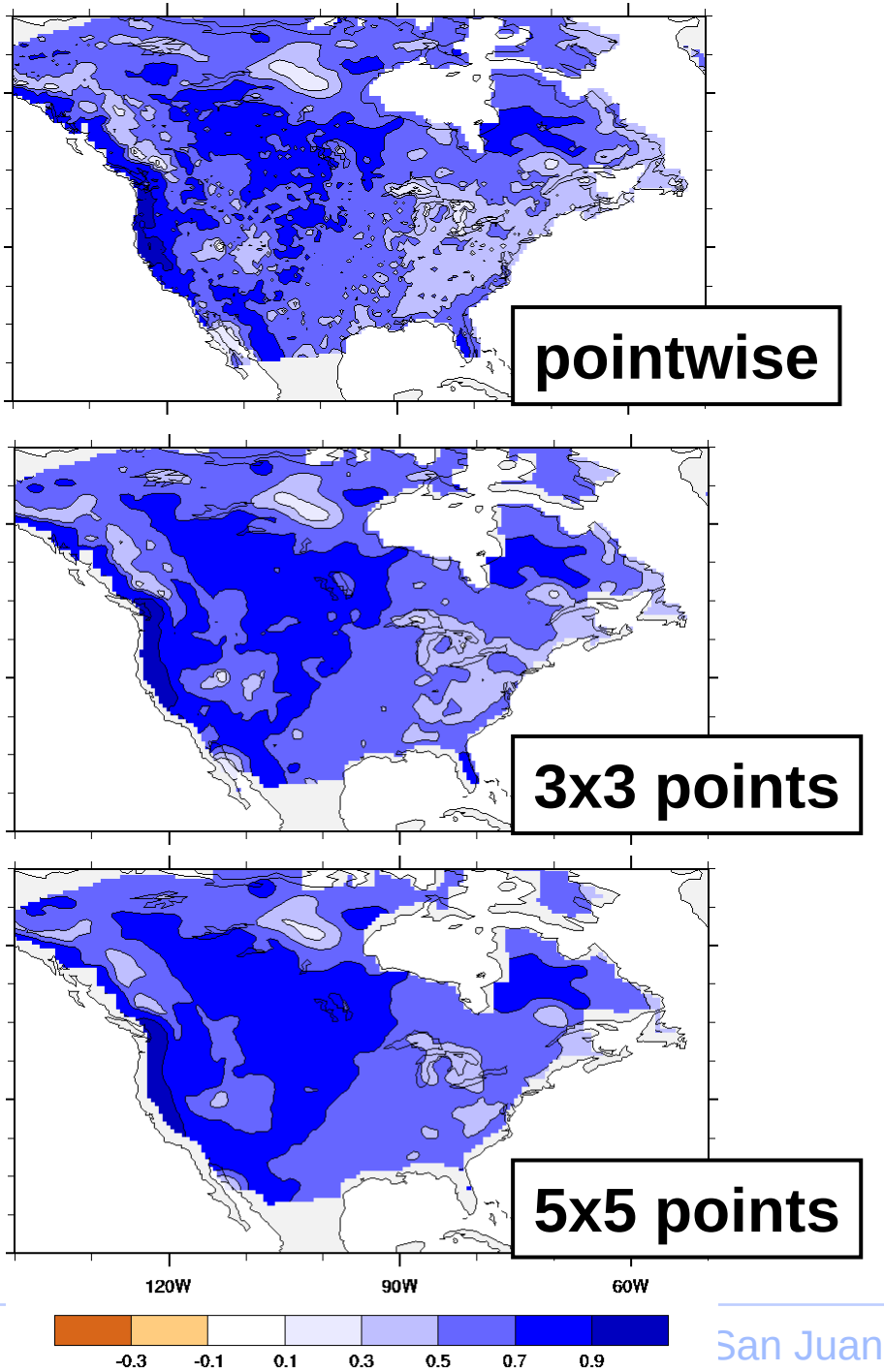
5x5





Spatial aggregation tends to improve correlation, but effect differs across the domain.

- Differs from model to model (MM5 shown here).
- Aggregation has more effect on individual models than on ensembles.
- Note improvement in central U.S. but not eastern U.S.



Aggregation has a greater effect on correlation in a model with spectral nudging.

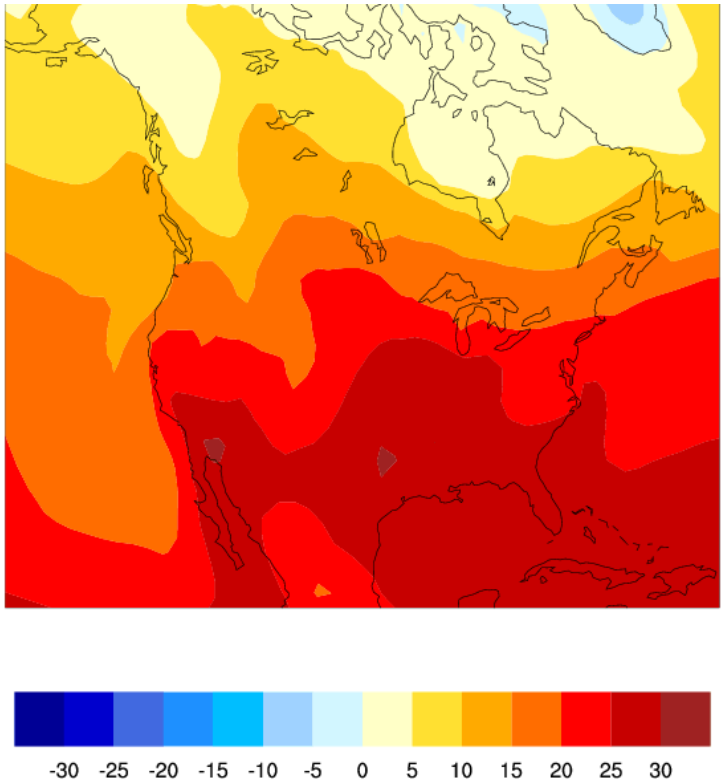
- Canadian RCM shown here.
- Note improvement in eastern U.S.
- **Hypothesis:** Large scales are better represented in a model with spectral nudging, so smoothing out small-scale irregularities produces more improvement.

Phase II (Climate Change) Results

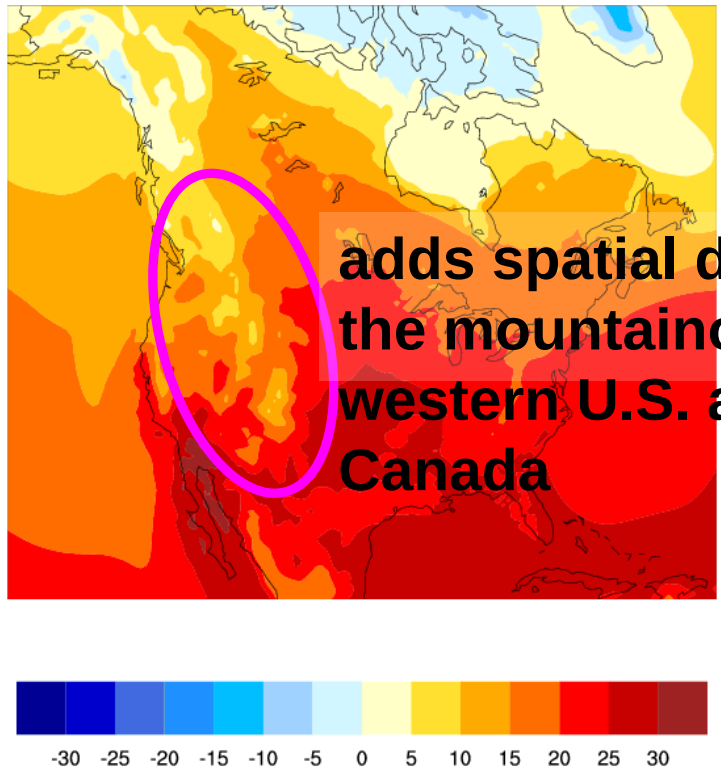
CCSM current climate vs. WRF

June-July-August surface temperature, 1980-1999

CCSM



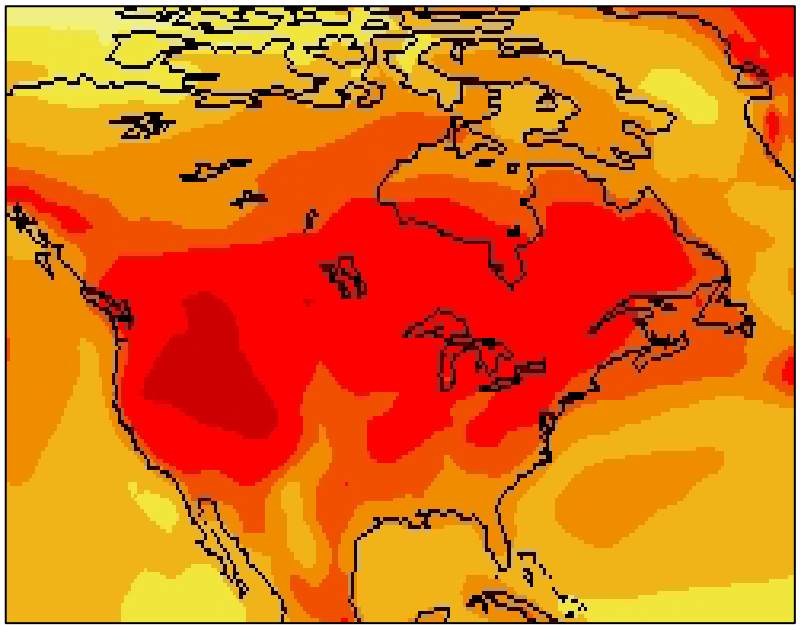
CCSM + WRF



adds spatial detail in the mountainous western U.S. and Canada

Summer Temperature Changes
2051-2070—1980-1999

CCSM



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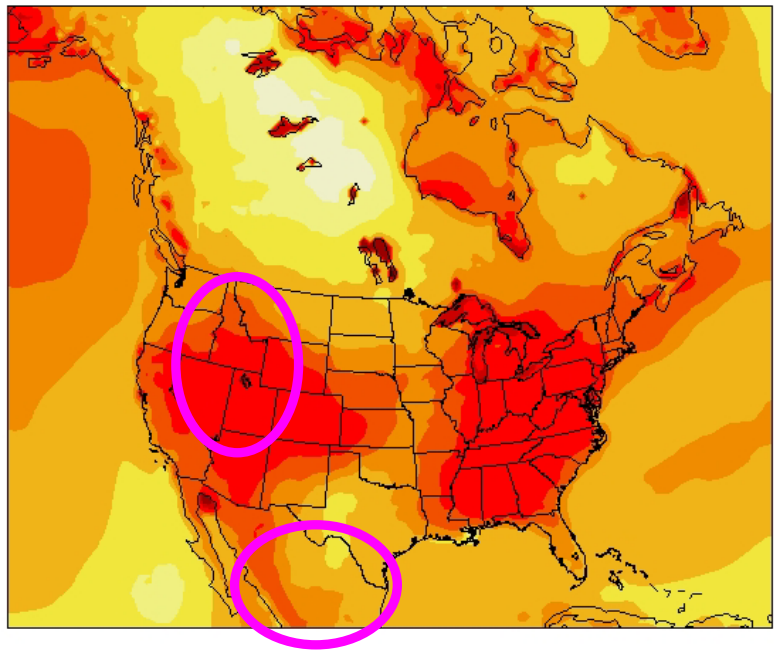
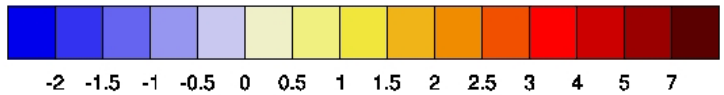
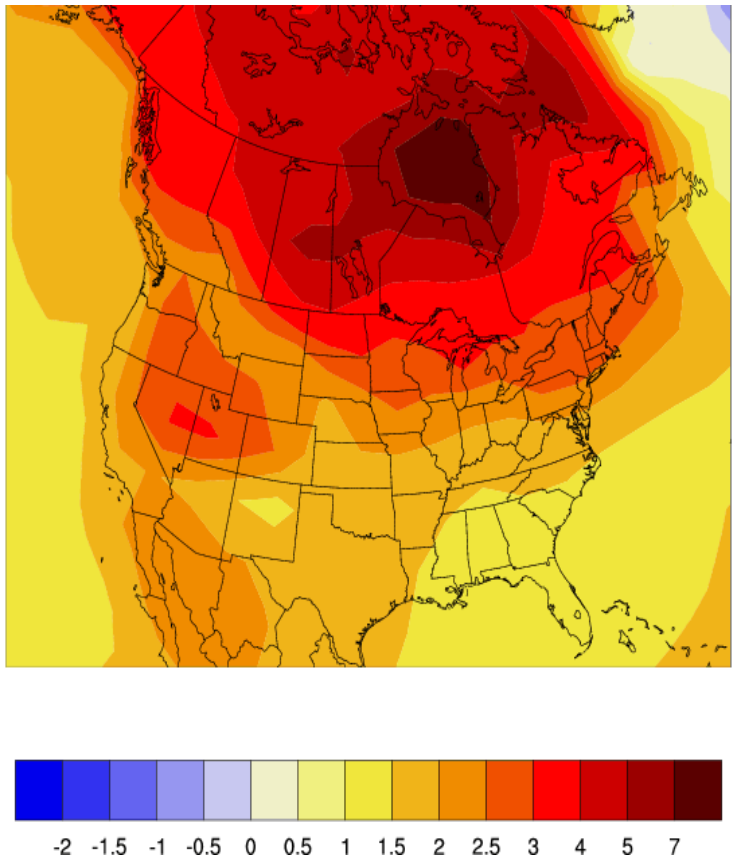


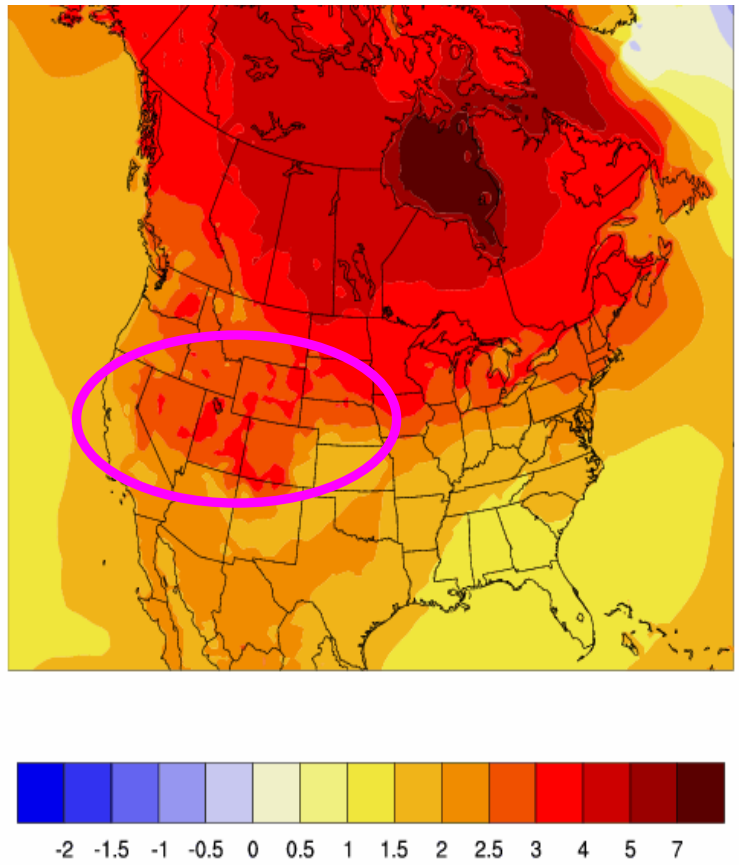


Change in Winter Temperature Canadian Models

CGCM3 Global Model

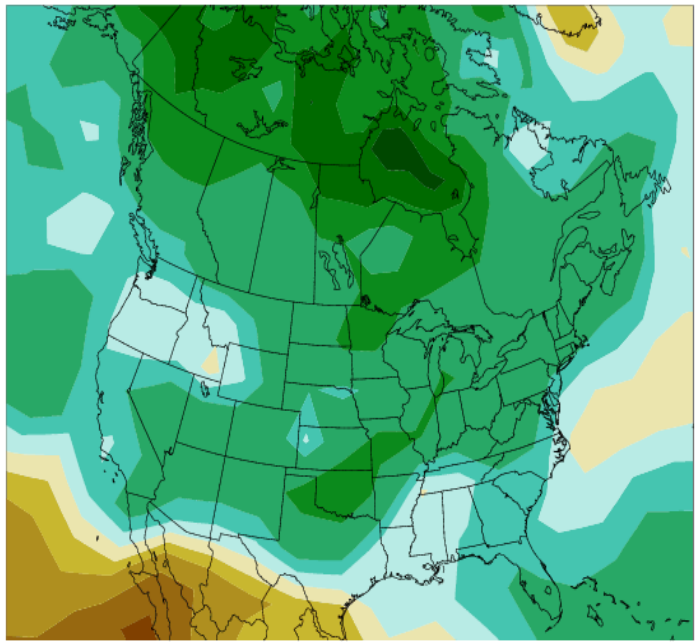


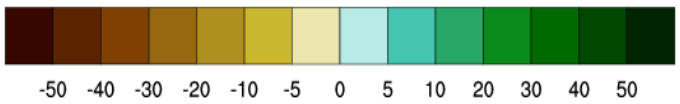
CGCM3 + Regional Model



Change in Winter Precipitation Canadian Models

CGCM3 Global Model





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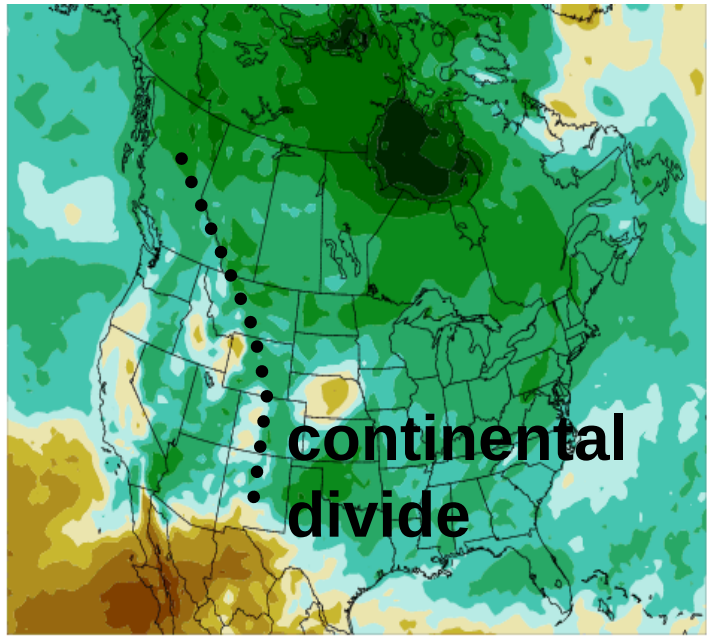
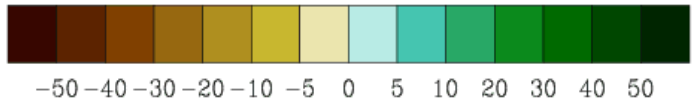
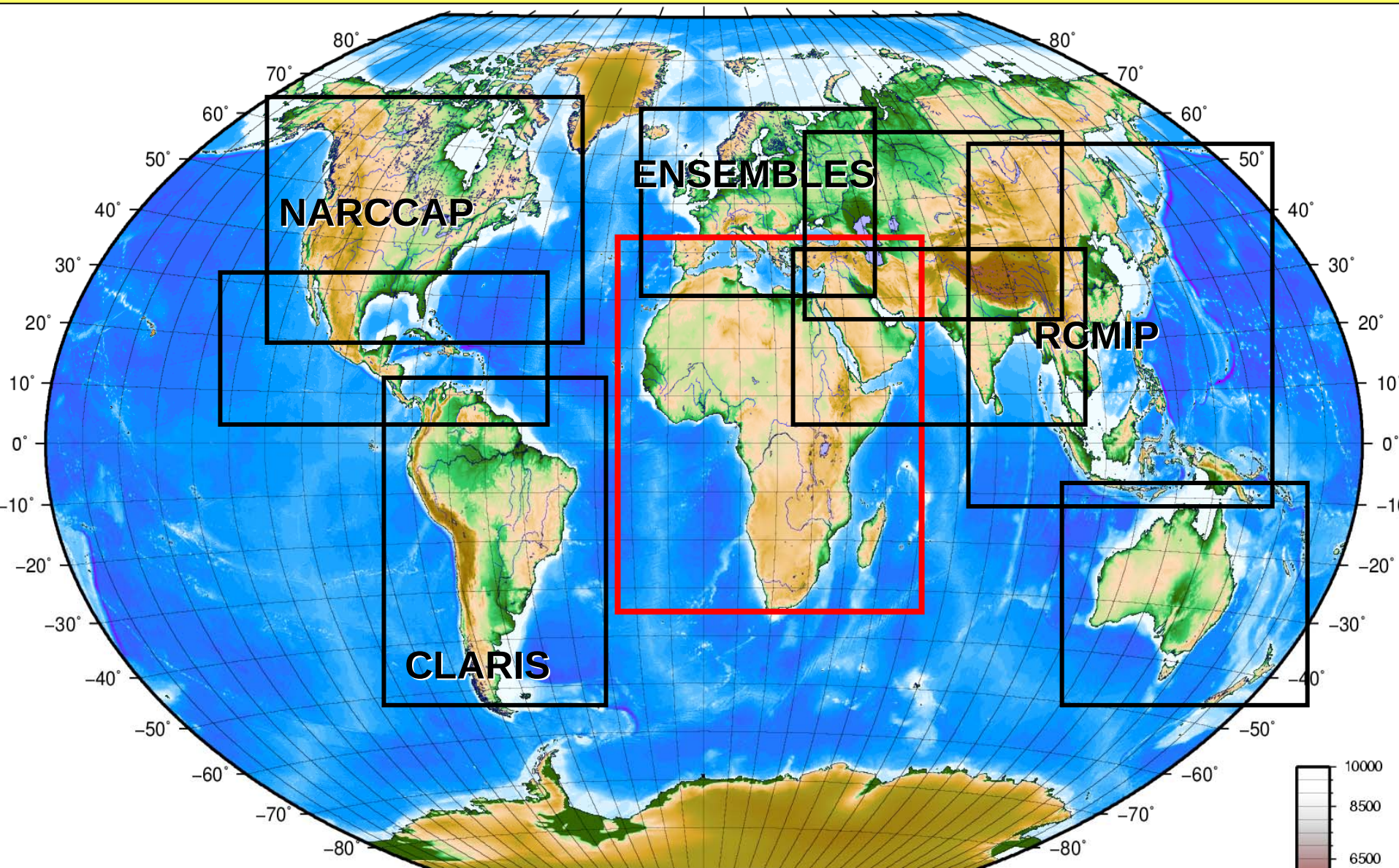




Another collaborative project CORDEX: Cooperative Regional Downscaling Experiment

- Provide a set of regional climate scenarios for 1950-2100 for most of the populated land regions.
  - includes near-term (decadal) scale
- Make the results readily available and useable to the impact and adaptation communities.
- Foster coordination between regional downscaling efforts around the world.

CORDEX domains



Scenarios and periods

- Emission scenarios: (a) RCP4.5 (b) RCP8.5 (c) RCP2.5
- Standard RCM resolution is 50 km
  - Groups are encouraged to test higher resolutions, but must do the standard
- Full transient runs 1950-2100 or time slices:

  1980-2010 (highest priority)
  2040-2070
  2010-2040
  2070-2100
  1950-1980 (lowest priority)

Current status

- A request to GCM groups to archive 6-hourly 3D model level fields was included in the CMIP5 output protocol.
  - The request was for at least 1 member of an RCP4.5 integration and if possible an RCP8.5 run also.
  - Not yet clear how many GCM groups will provide data but at least 5-6 GCMs seems likely.
- The project is still getting started so this is a good time to get involved and give suggestions
- Sign up for the CORDEX mail list at:

http://mesonet.agron.iastate.edu/mailman/listinfo/cordex

Summary

- NARCCAP Phase I runs are complete:
  - Skill tends to deteriorate west to east.
  - Only weak evidence for a spread-skill relation.
  - Adding large-scale information to the RCM interior can improve accuracy for some regions.
  - **How do we create ensembles?**
- Phase II is nearing completion:
  - RCMs reflect GCM predictions but add detail mainly due to better representation of terrain.

THANK YOU!

Project web site:

http://www.narccap.ucar.edu

Data portal:

http://www.earthsystemgrid.org/forward.htm?forward=narccap

Email:

Any user (such as arritt@iastate.edu)

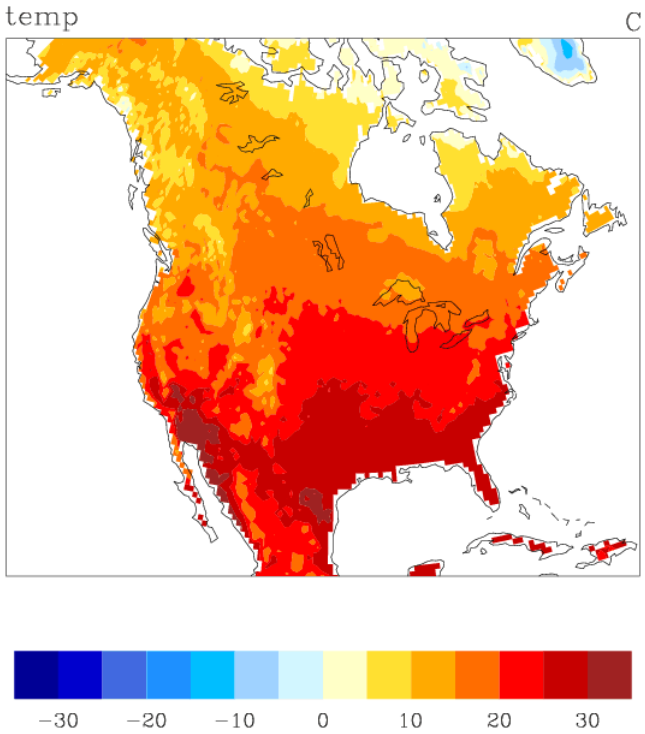
CORDEX: Basic approach

Develop a matrix of RCD simulations that employ:

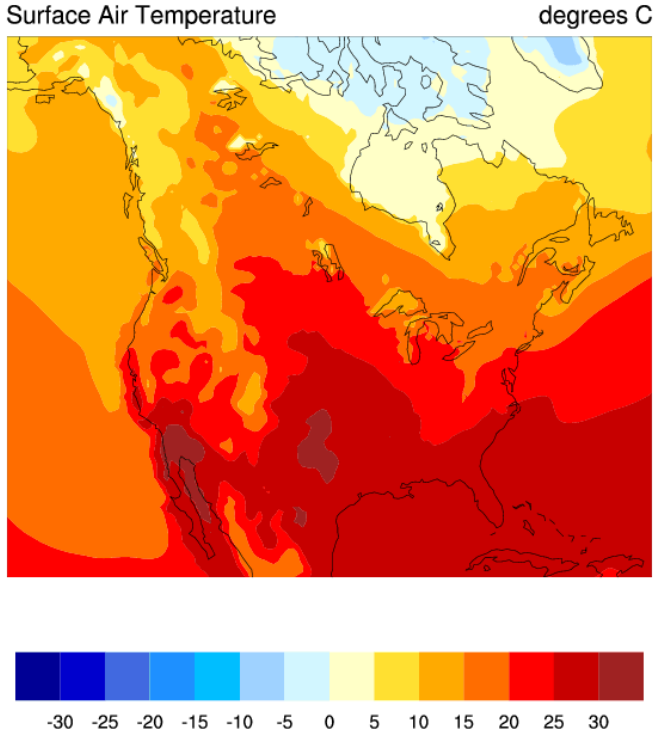
1. Multiple GCMs as boundary conditions (BCs).
2. Multiple realizations of each GCM as BCs.
3. Multiple RCMs driven by a given GCM over a given domain.
4. More than one scenario of climate change.
5. Common RCM domains and resolution.
6. Common RCM output variables, frequency, and format.
7. Make results available online for access and use.

WRF summer temperature vs Observations (Phase I)

UDEL obs., JJA seasonal avg, 1980-2004

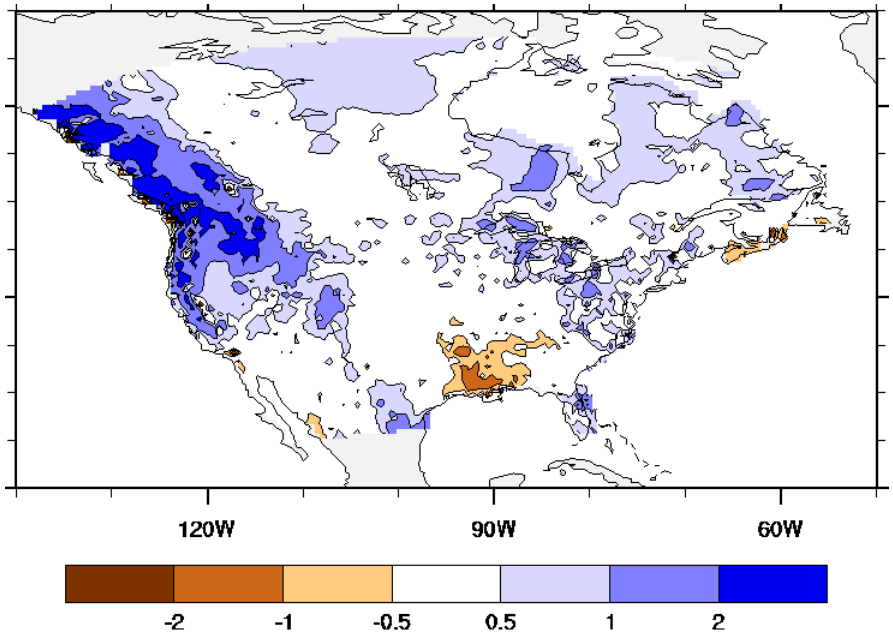


WRFP+NCEP, JJA seas. avg, 1980-1999

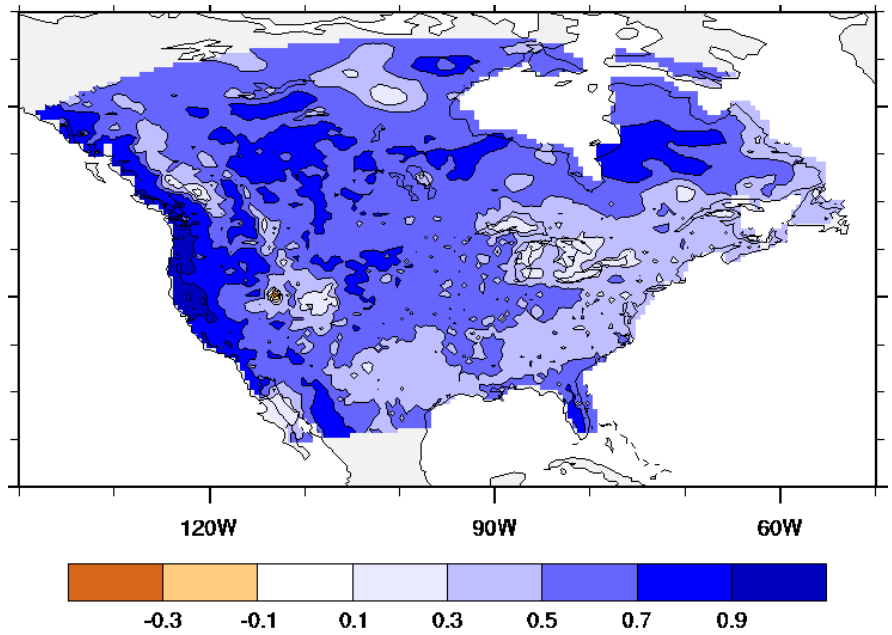


Bias of the ensemble mean and correlation of ensemble monthly time series of precipitation with observations, 1981-2002.

Bias



Correlation of monthly time series



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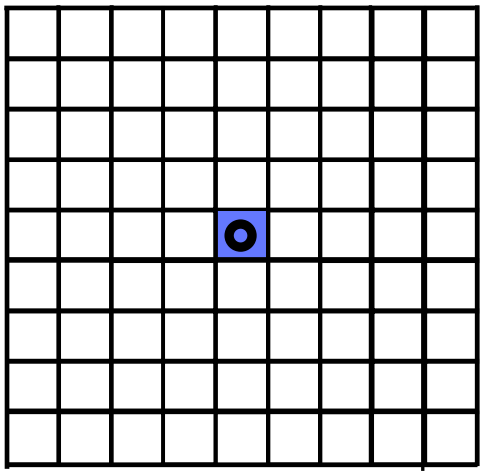

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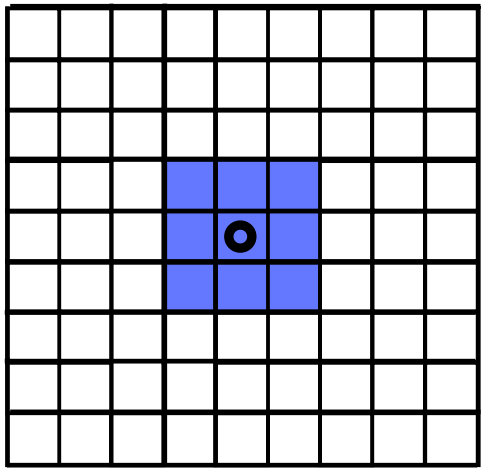
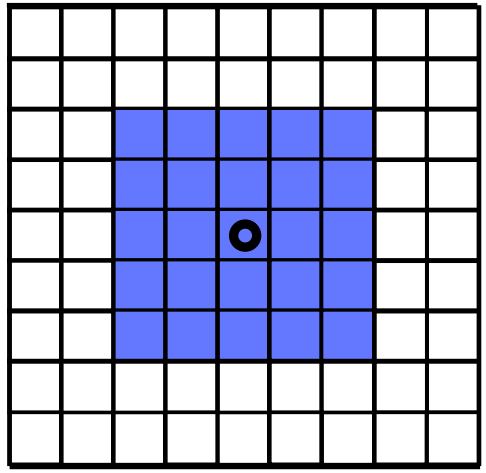
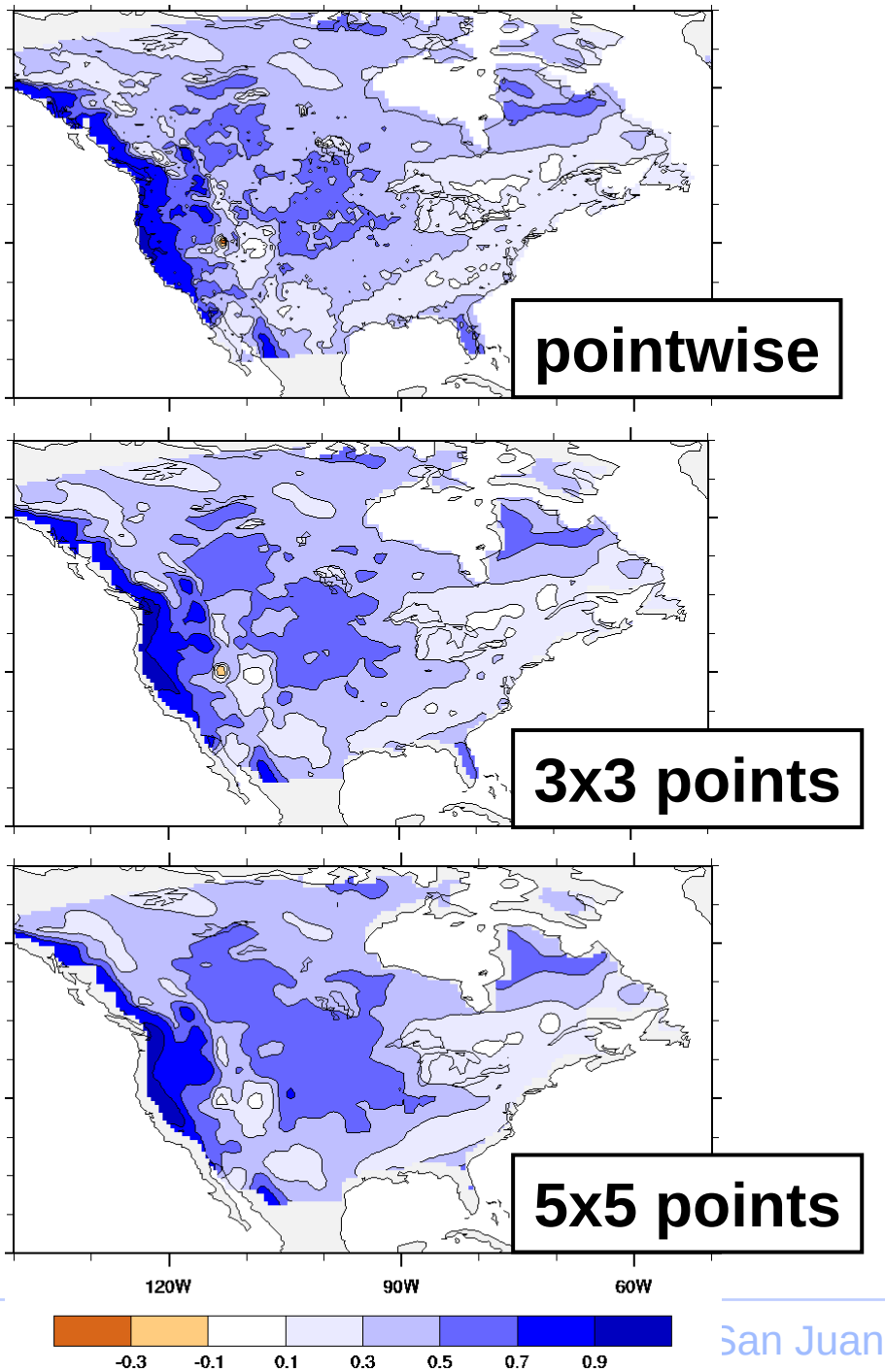


5x5





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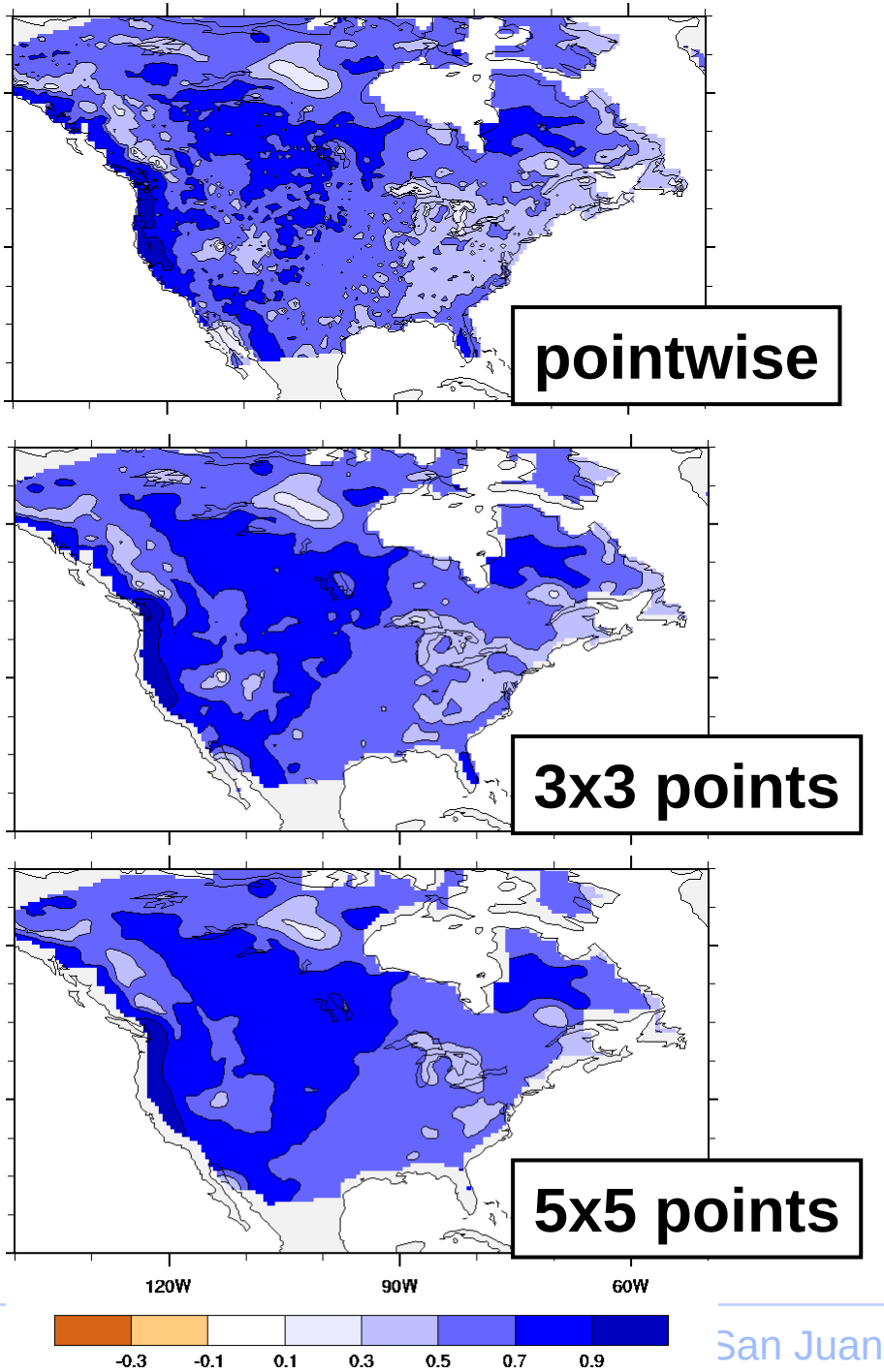

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