Regional Climate Modeling Efforts for the Western United States: Systematic Comparisons of Historical Projections based on Dynamical and Statistical Downscaling

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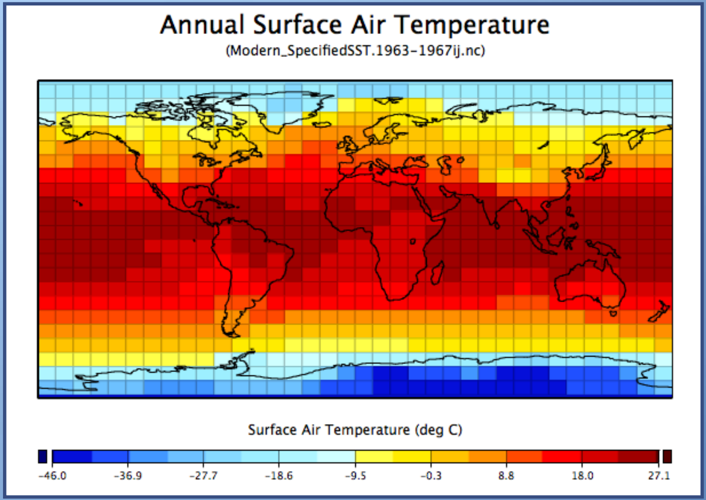
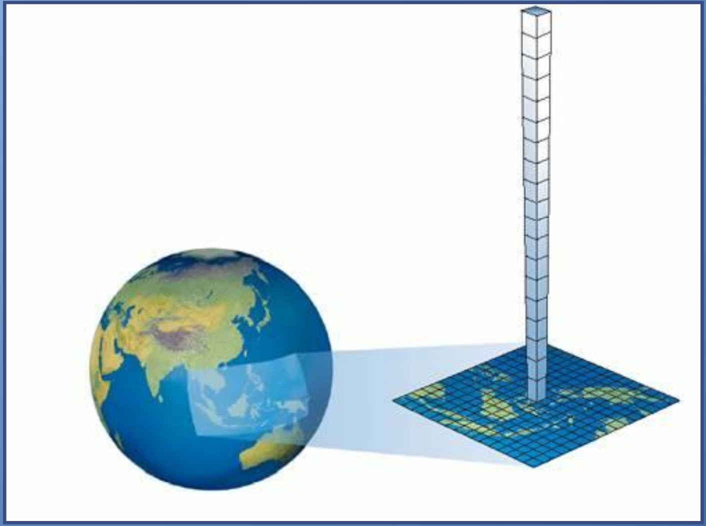
Climate Models and Downscaling

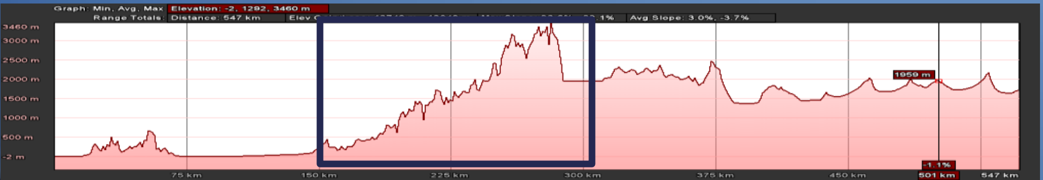
- Climate modeling is used to attempt to reconstruct the past and predict the future (long time periods)
- Most climate models used currently have a global scale, referred to as GCMs
  - Running a model over the entire globe for a long period of time takes a lot of computing resources!
- Global climate models tend to have large grid cells (resolution)
  - 100-300 km grid
- Downscaling is the process of taking the results from global climate models and using statistics, modeling, or a combination of the two to achieve regional results

Why do we want regional scale predictions?

- On what scale do we need information?
  - What end product are we interested in?
    - Hydrological modeling?
    - Ecosystem modeling?
    - Urban modeling?
    - Crop modeling?
  - Maurer & Hidalgo (2007) – Impact scales of <12 km needed
  - So how do we get to 12 km from 100+ km scales?







Overview of Downscaling

- Dynamical Downscaling
  - Involves running models, referred to as Regional Climate Models (RCMs) to predict climate on a smaller scale (regional or local)
  - GCM outputs drive the boundary conditions for long term simulations
  - Weather forecast models are adjusted to take into account changing forcing over the long term
    - E.g., Greenhouse gases
- Statistical Downscaling
  - Uses what we know from observations and models to interpolate to regional scales
  - "Bridging the gap" between GCM and scales necessary for climate change impact studies
  - Methods:
    - Bias corrections
    - Regression analysis

Objectives of DRI-RCM

Production of ***regional climate scenarios*** for impact assessments

- Add value to the GCM ensemble prediction system:
  Use regional climate model (RCM) and other downscaling methods to predict phenomena such as orographic precipitation and local climate responses
- Develop an ensemble system based on global and regional climate system models.
- Evaluate RCM downscaling products against quality-controlled, high-resolution gridded data sets.

Regions of Interest:

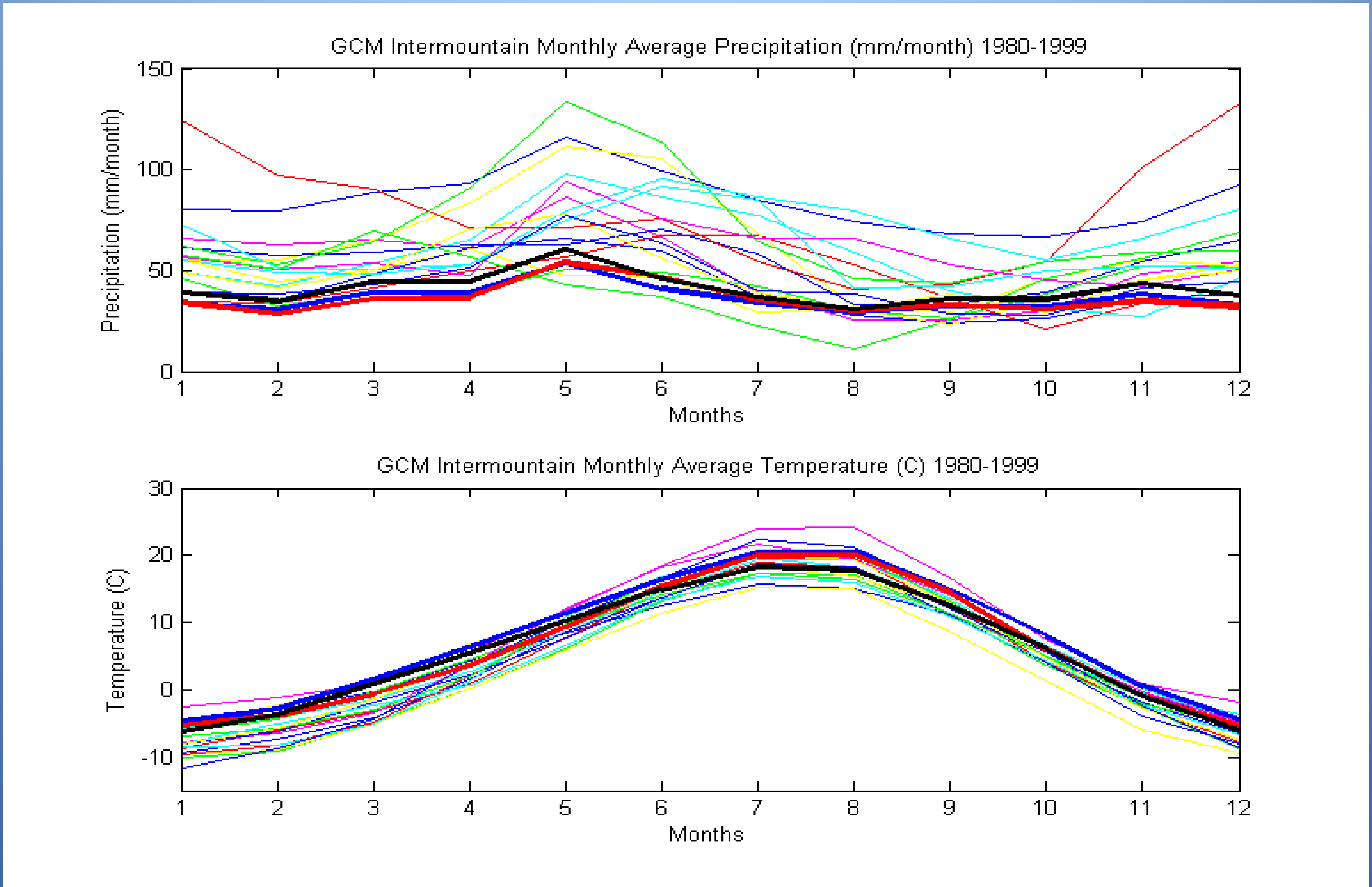
- 3 Regions in NV
  - Western NV (Sierra NV)
  - Eastern NV
  - Monsoon NV (Southern NV)
- 3 Regions in NM
  - Western NM
  - Southeastern NM
  - Mountain NM
- 2 Regions in ID
  - Northern ID
  - Southern ID
- 3 Larger Regions
  - Intermountain West (NV, UT)
  - Sierra NV and Cascades
  - Monsoon region (Arizona, NM)

Regions of Interest

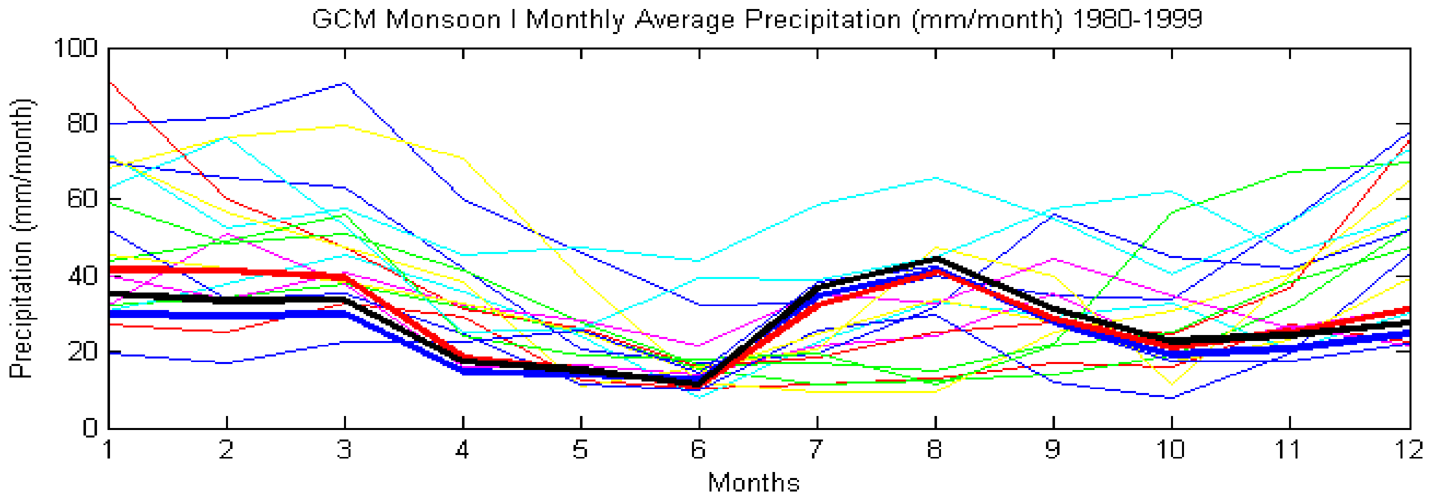
Downscaling efforts thus far

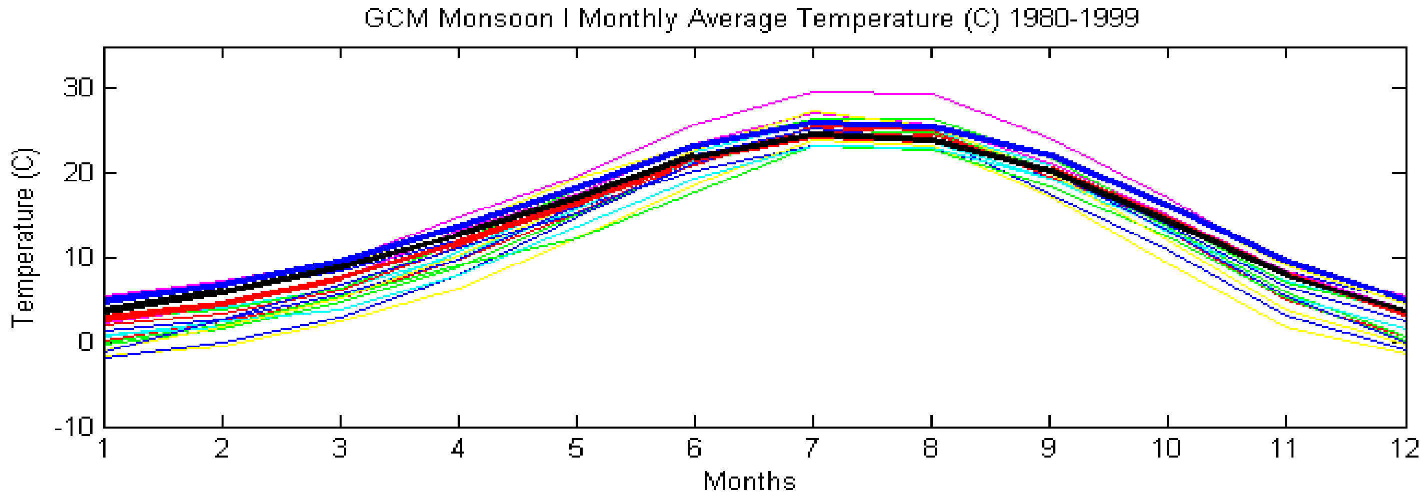
	GCMs	NARCCAP	Bureau of Reclamation	DRI Dynamical Downscaling	DRI Statistical Downscaling
Method	Global atmosphere/ ocean coupled models	Dynamic downscaling using 6 different RCMs	Statistical downscaling of GCM results	WRF-RCM used to dynamically downscale GCM results	Statistical downscaling of GCM results
Drivers	Top, bottom boundary conditions	4 GCMs	16 GCMs	2 GCMs	2+ GCMs
Emissions Scenarios	A1, A2, B1, B2 and variants	A2	B1, A1b, A2	A2	B1, A1b, A2
Grid Size	~100 km	50 km	12 km	36 and 12 km	4 km to Point based
Coverage	Global	North America	United States and parts of Canada and Mexico	Western United States: NV, NM, and ID	Western United States
Parameters	Most Atm. & Oceanic variables	Most Atm. variables at: surface and multiple vertical levels	Precipitation, T_{min}, and T_{max}	Most Atm. variables at: surface and multiple vertical levels	Precipitation, T_{min} and T_{max}
Data Availability	Monthly, 6 hourly (some), or by request	3 hourly	Monthly	1 hourly	Daily -monthly

GCM Comparison:
Intermountain Region

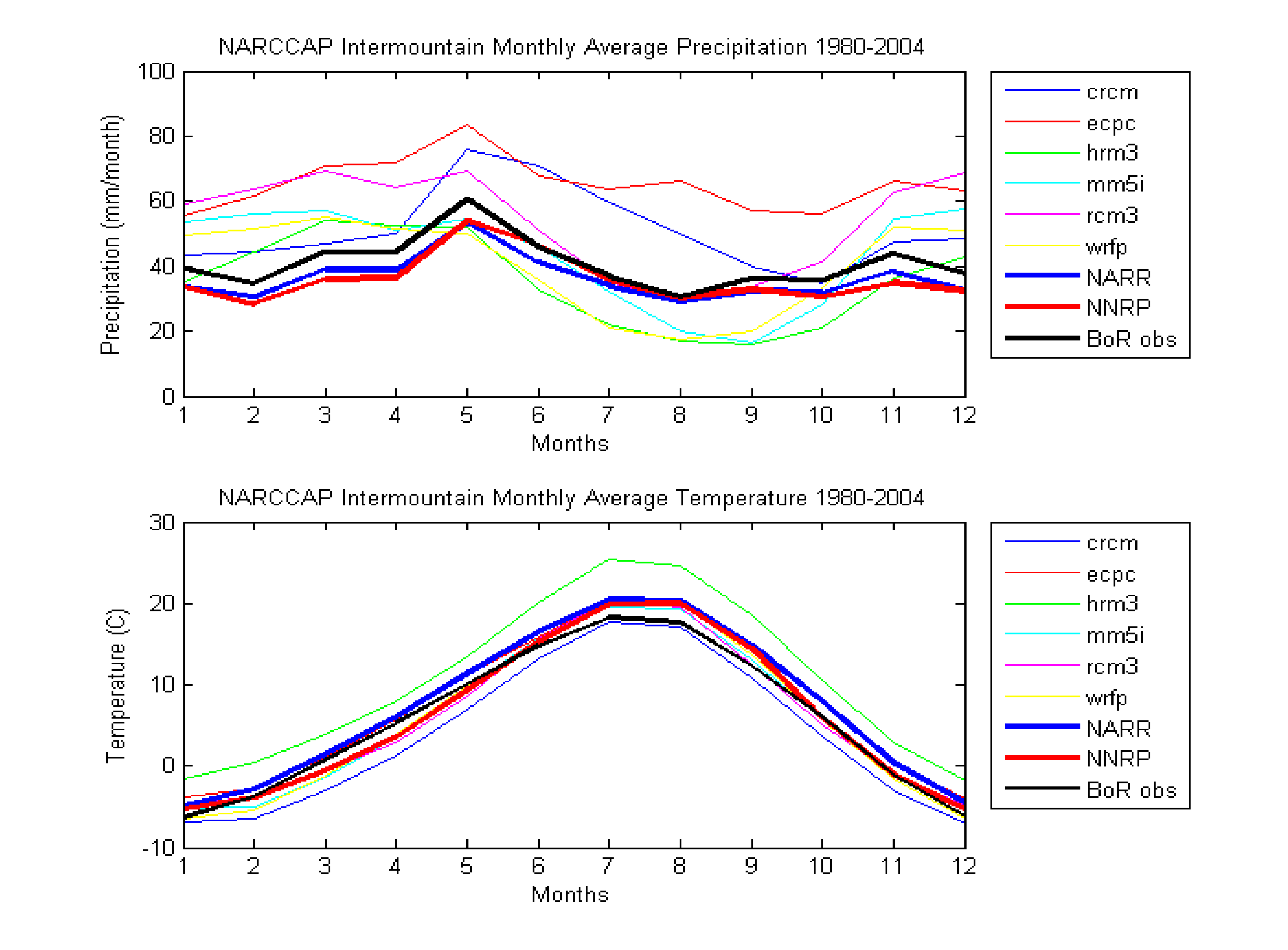


GCM Comparison:
Monsoon Region

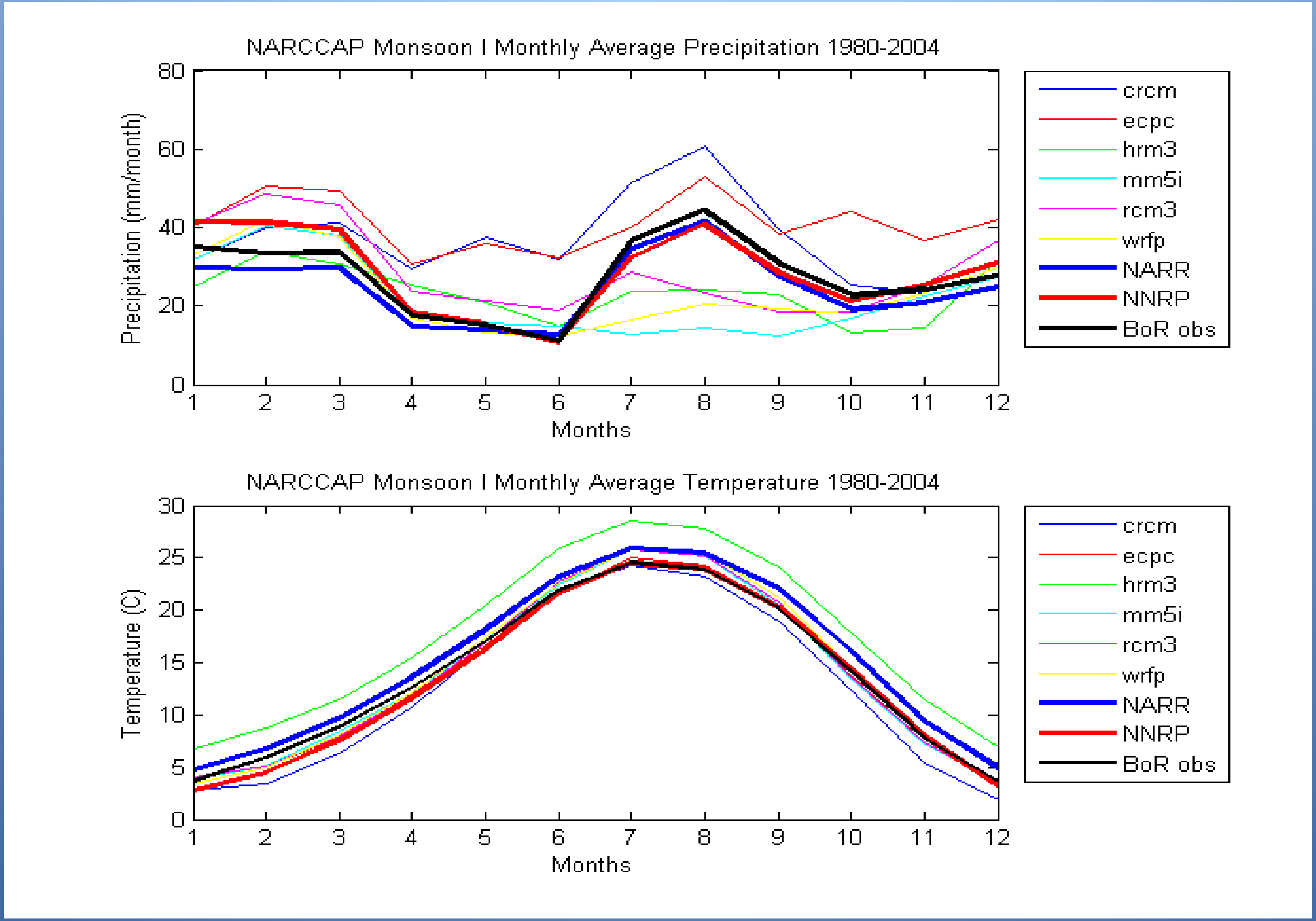




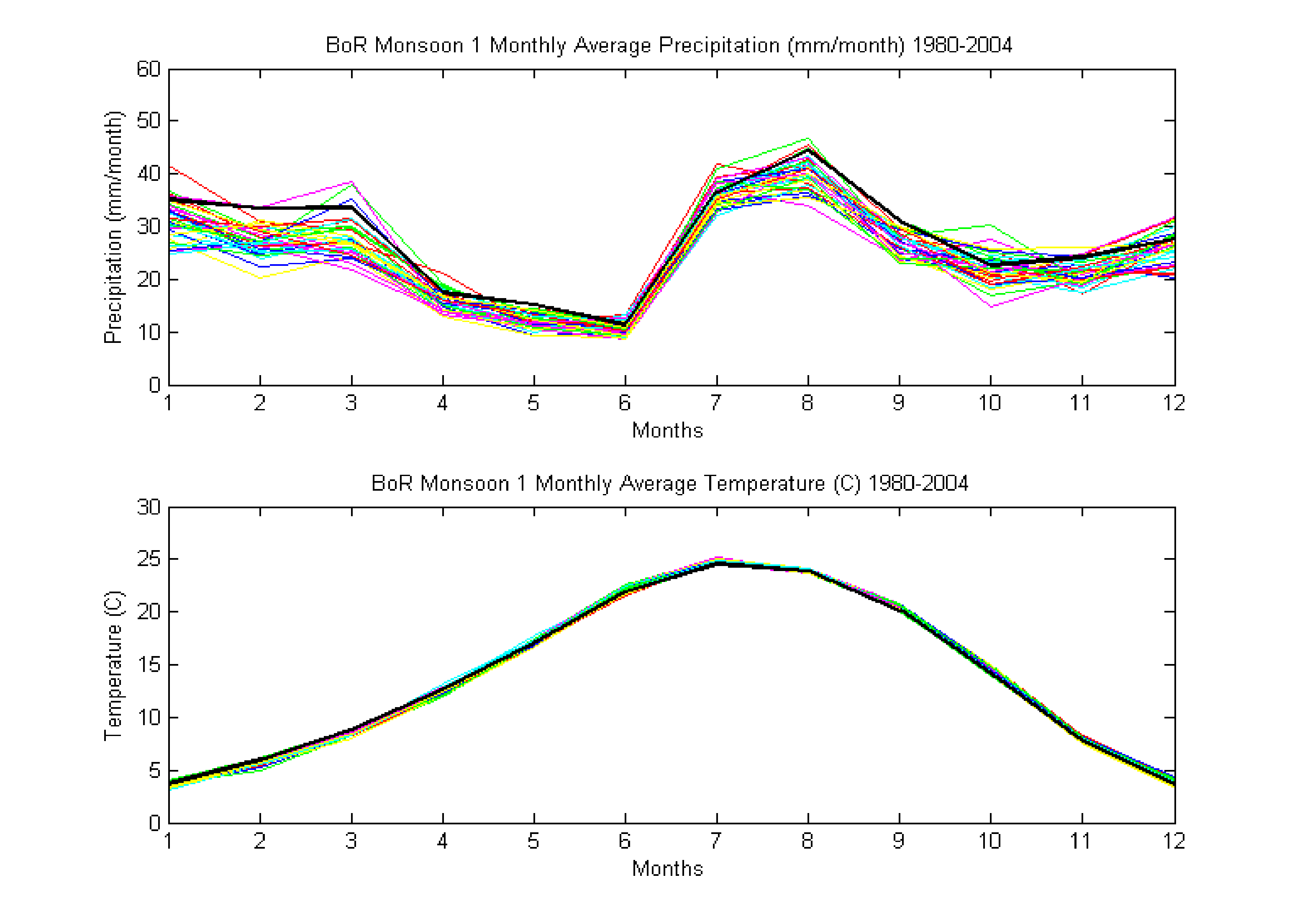
NARCCAP Comparison:
Intermountain Region



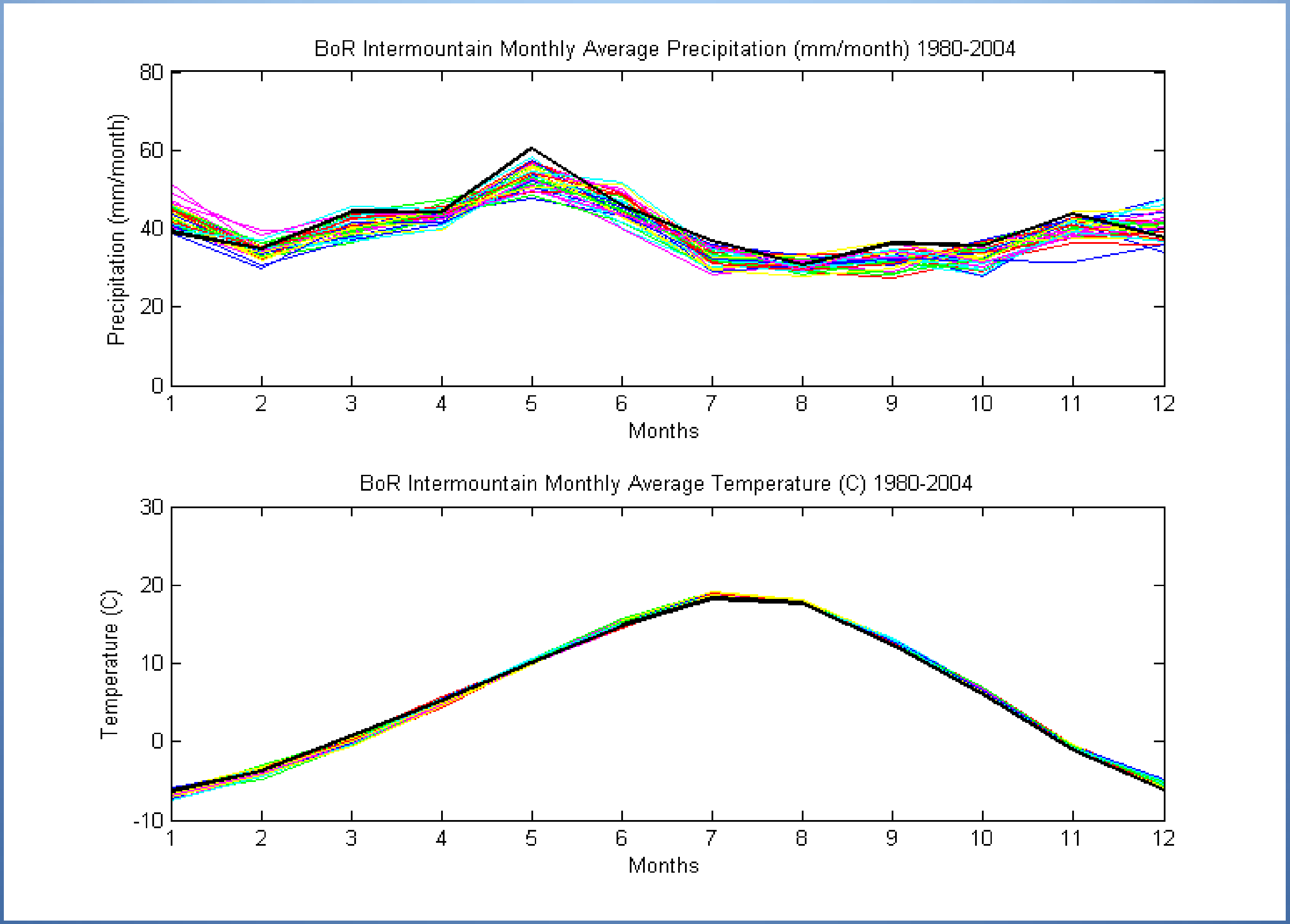
NARCCAP Comparison:
Monsoon Region



BOR Comparison:
Monsoon Region

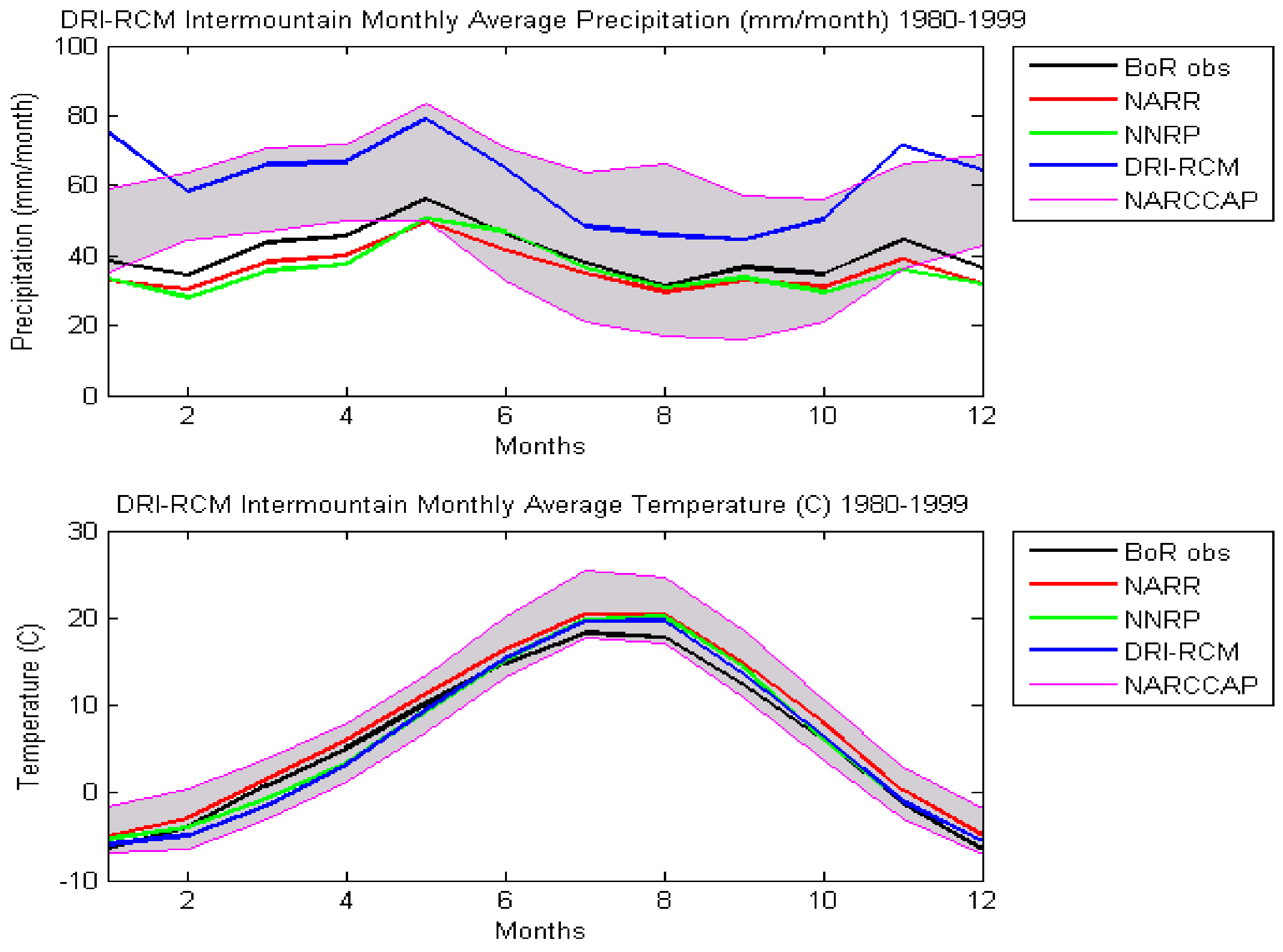


BOR Comparison:
Intermountain Region

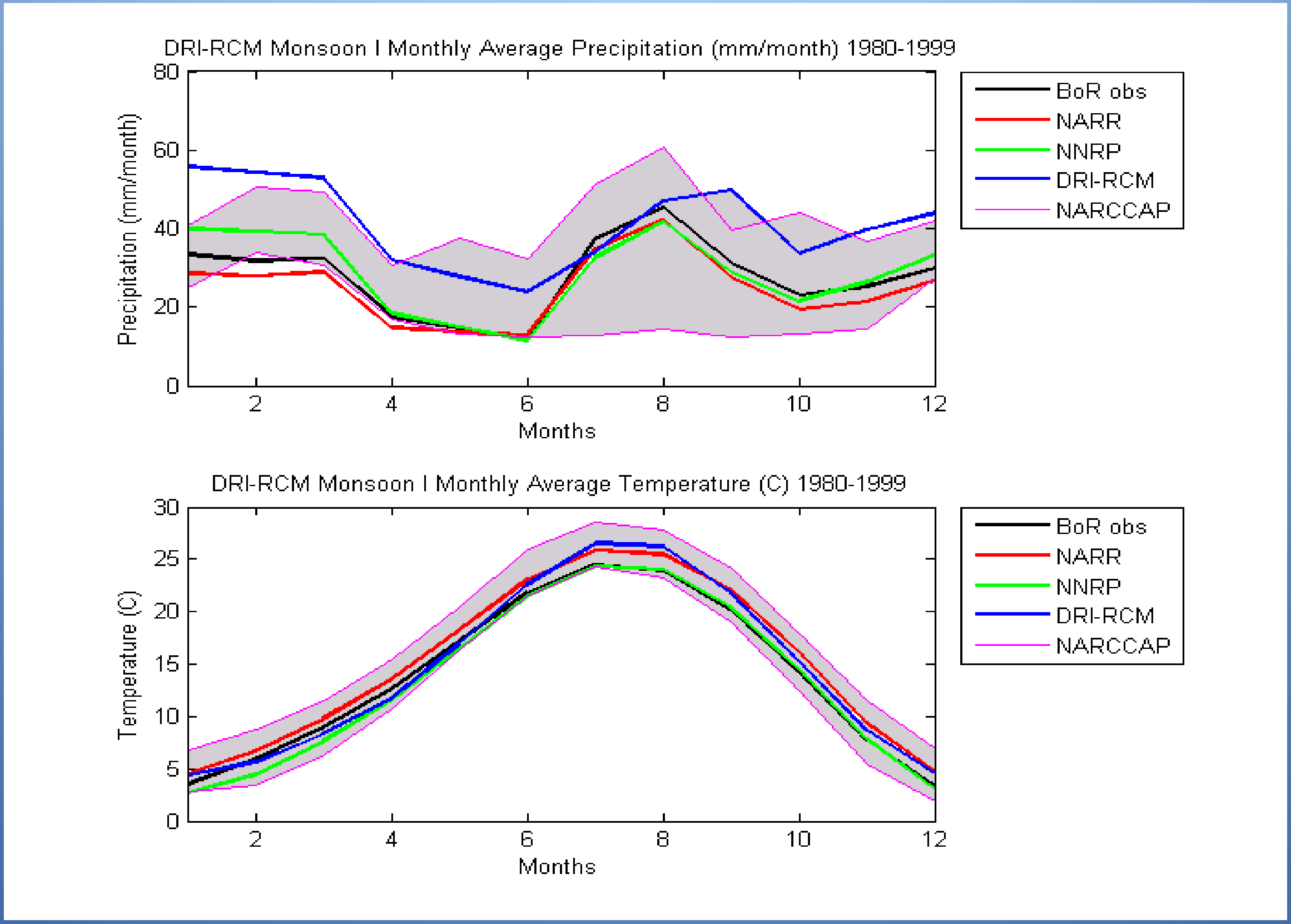


DRI-RCM Comparison

Intermountain Region

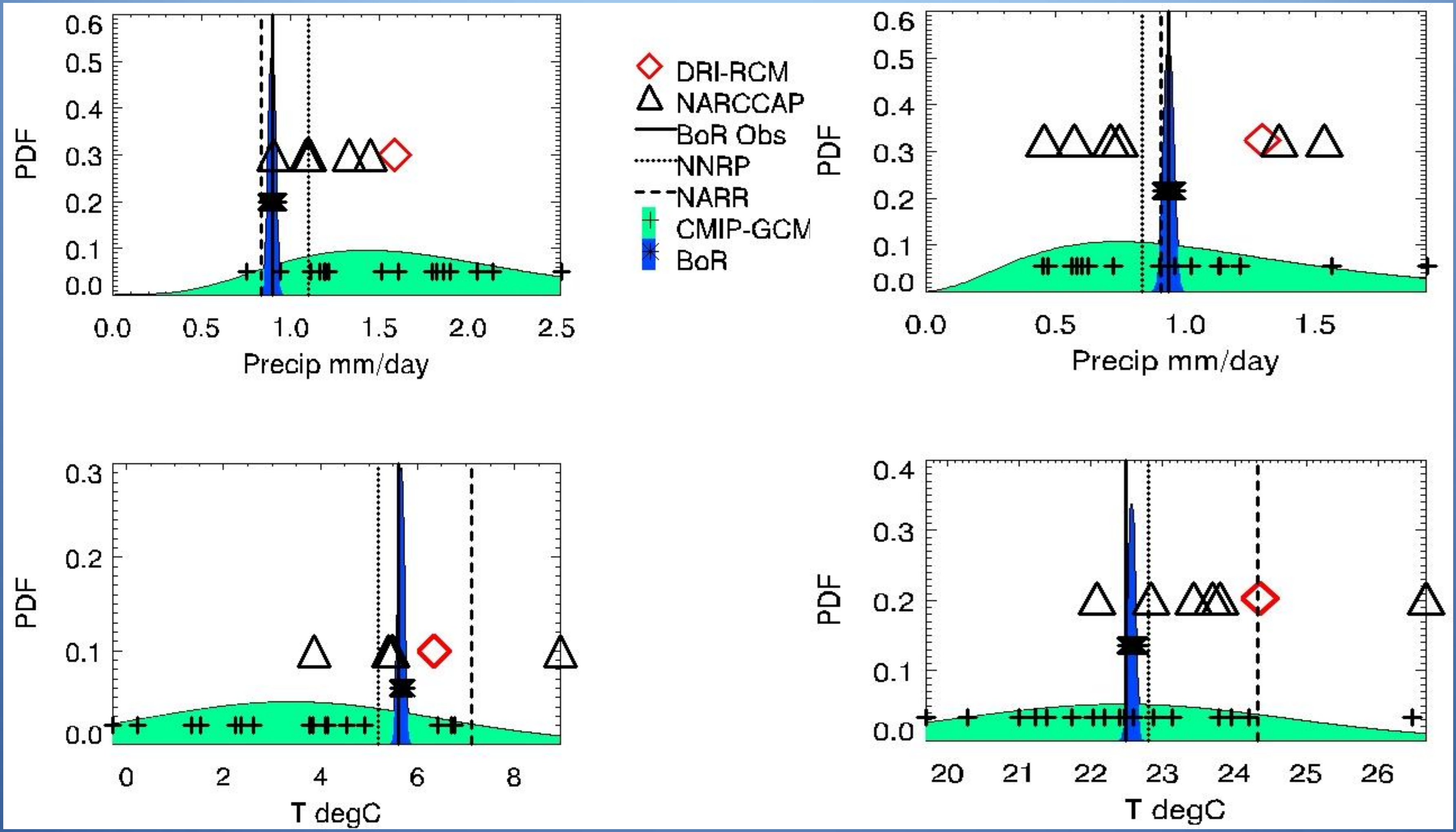


DRI-RCM Comparison
Monsoon Region



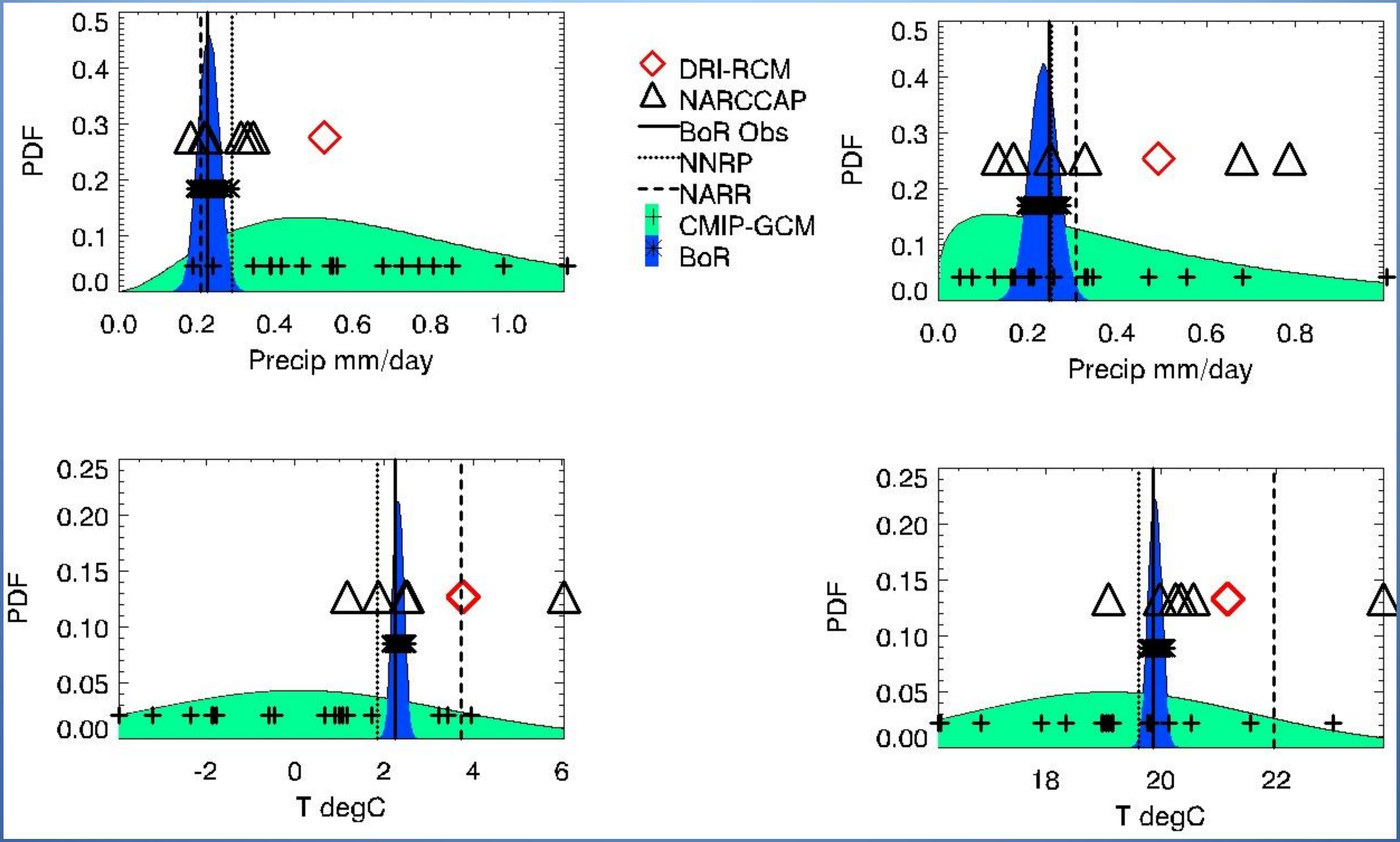
AZ-NM: 1980-2000

Mean (Nov–Mar) Mean (Jun-Sep)



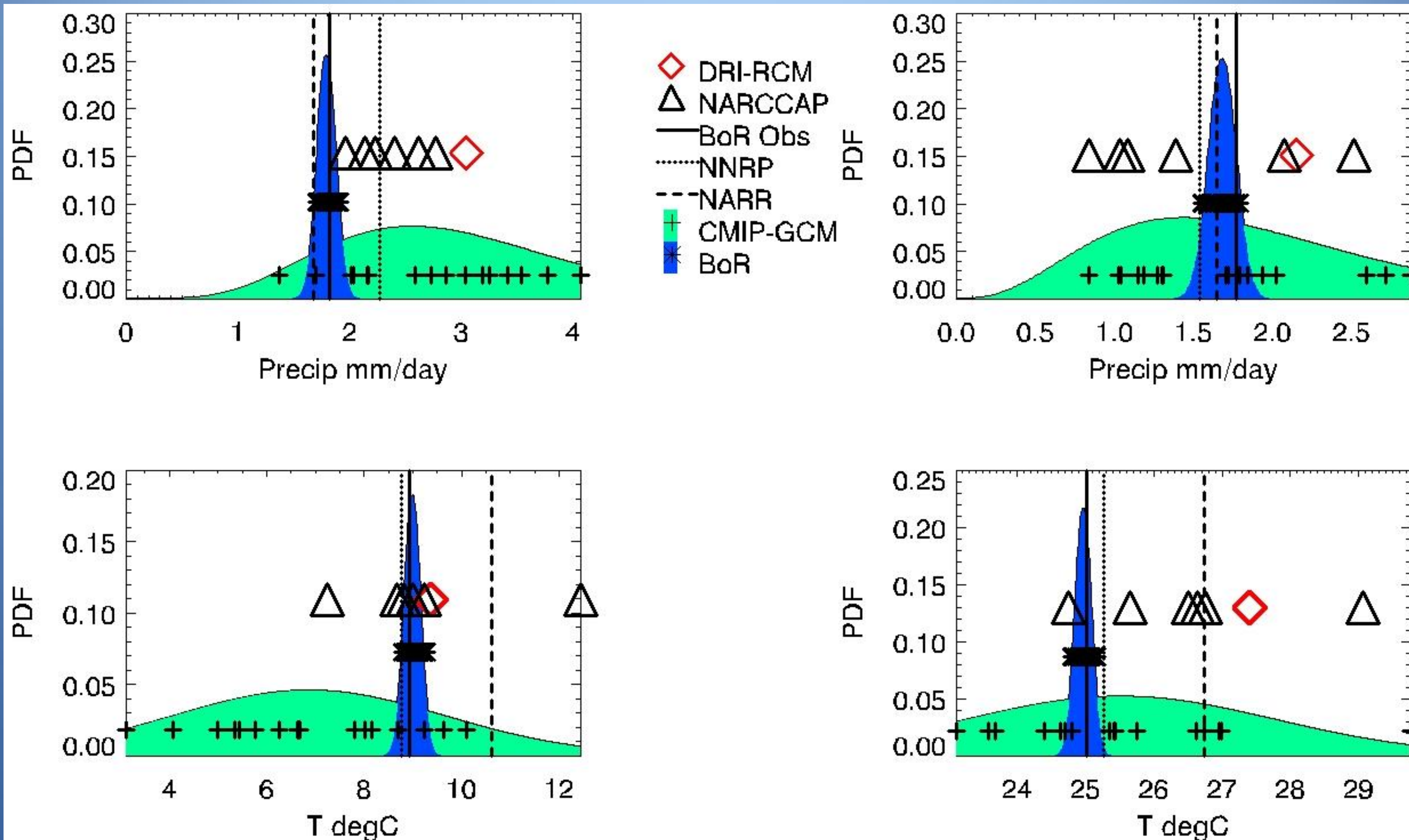
AZ-NM: 1980-2000

q_10 (Nov–Mar) q_10 (Jun-Sep)



AZ-NM: 1980-2000

q_90 (Nov–Mar) q_90 (Jun-Sep)



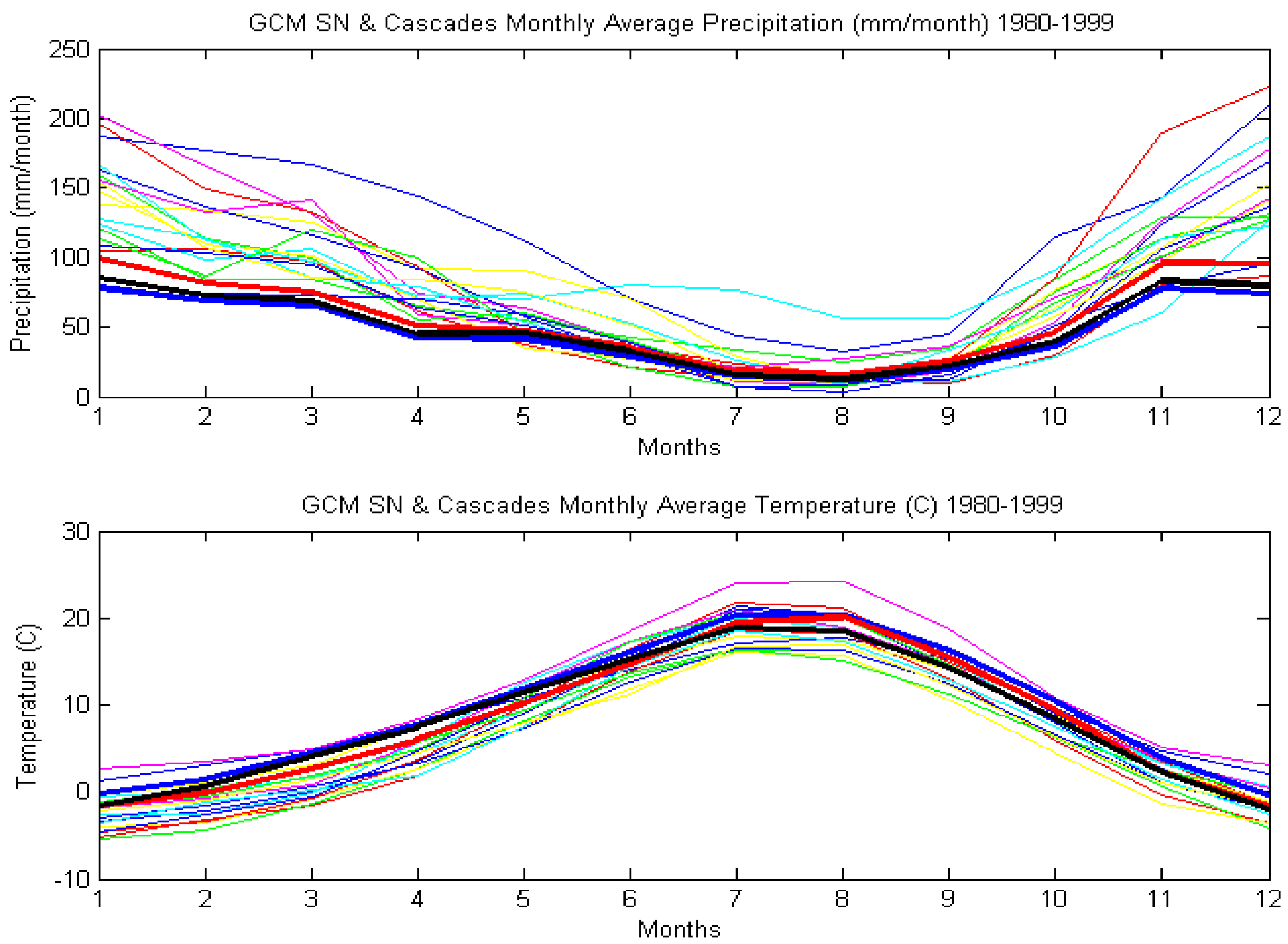
Conclusions

- Observation gridded data sets do not match each other
  - Scale (spatial-temporal) issues, data assimilation issues
- IPCC-A4 (CMIP-GCM) models tend to overestimate winter precipitation and some underestimate summer precipitation
- IPCC-A4 (CMIP-GCM) models are cold biased while mean summer temperatures are more consistent
- BoR data converges towards the observations
  - Not surprising because the bias correction was determined using this same time period
- NARCCAP RCMs solutions (forced with NNRP) tend to concentrate around observations but spread is relatively large especially for precipitation
- DRI-RCM overestimates rainfall, likely a systematic bias

References

- Maurer, E.P., and H.G. Hidalgo, 2007 Utility of daily vs. monthly large-scale climate data: An intercomparison of two statistical downscaling methods. *Hydrology and Earth System Science Discussions* 12: 551-563.
- Maurer, E.P., A.W. Wood, J.C. Adam, D.P. Lettenmaier, and B. Nijssen, 2002, A Long-Term Hydrologically-Based Data Set of Land Surface Fluxes and States for the Conterminous United States, J. Climate 15(22), 3237-3251.
  - Data available at: http://www.engr.scu.edu/~emaurer/gridded_obs/index_gridded_obs.html

GCM Comparison:
Sierra NV and Cascades Region



NARCCAP Comparison:
Sierra NV and Cascades Region