Component: Climate Modeling

Lead: Darko Koracin, DRI
Steering Committee Members:
Scott Bassett, UNR; Zhongbo Yu, UNLV
Postdoctoral Associate:
John Mejia
Graduate student:
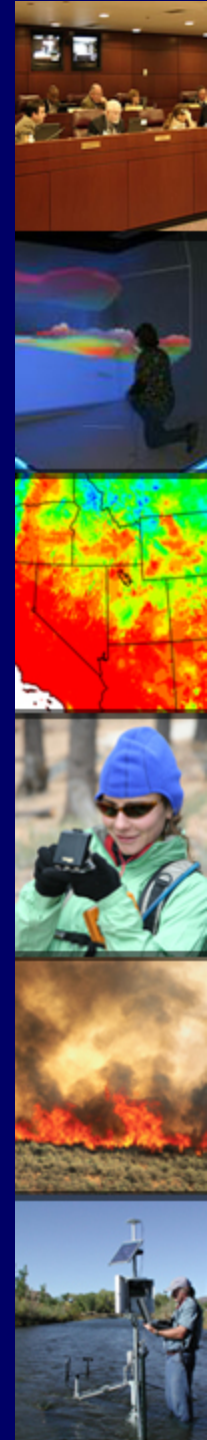Benjamin Hatchett, DRI
Computer support:
Travis McCord, Ramesh Vellore, Paul Neeley DRI

2 February 2010, Las Vegas, NV

Nevada Infrastructure for Climate Change Science, Education, and Outreach

Research Goals

- Provide improved regional climate models to get accurate climate trends in Nevada (inputs to hydrological models; parameterization of land-atmosphere interactions; aerosol contribution to climate; feedback interactions among atmosphere, hydrology, and ecological processes; linking physical and economic models)

- Assess future hydrological resources, their variability, uncertainties, and socio-economic impact. Focus on water demand and supply in rural and urban Nevada. Select critical areas for model prediction applications.

- Assess impact of climate change on air quality and urbanization

- Provide an integrated GIS system (Geoinformatics) for water, energy, and economic parameters

- Collaborate with partner EPSCoR states: Exchange of information, modeling applications, and workforce development
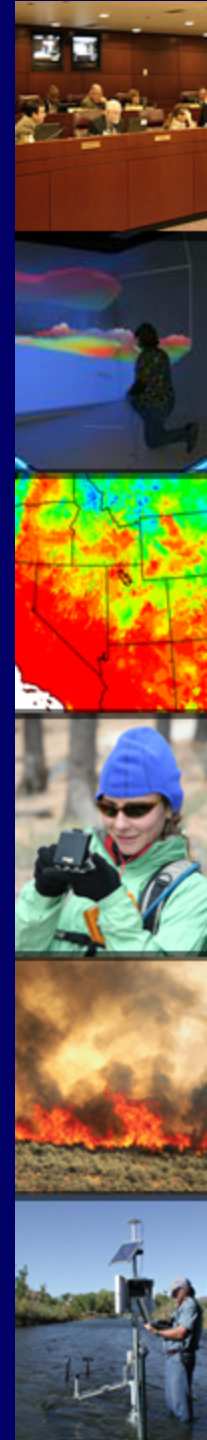
Overview - Infrastructure

- DRI - Infrastructure
  - Personnel
    - John Mejia – Postdoctoral Associate (Oct 2009)
    - --- *Regional climate modeling and dynamical downscaling*

    - Benjamin Hatchett – M.S. graduate student (Jan 2009)
    - --- *Statistical regional downscaling*

    - Linlin Pan – Postdoctoral Associate (came in Nov 2009 and left in Dec 2009)

    - Eric Wilcox – Climate Modeler – faculty position – offer submitted
    - --- Global observational networks and global and regional climate modeling

  - Computer system
    - SUN Fire system (8 chassis; ten blades with 16 GB of memory and 146 GB disk; total of 640 processors)
    - Data storage of 140 TB
    - Rocks (5.2.2) Cluster Management

- Scott Bassett – UNR
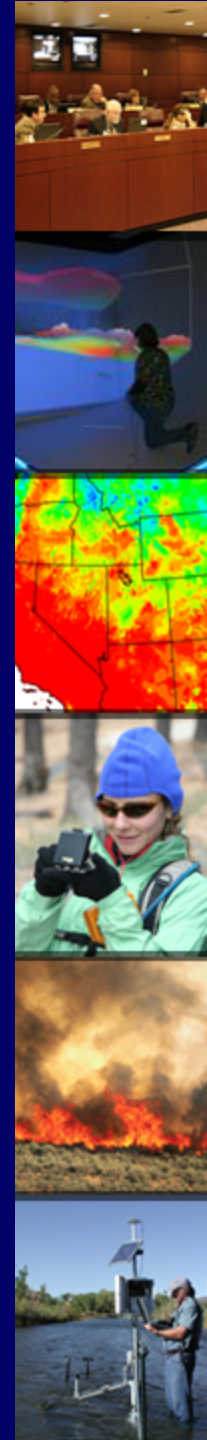
- Zhongbo Yu - UNLV
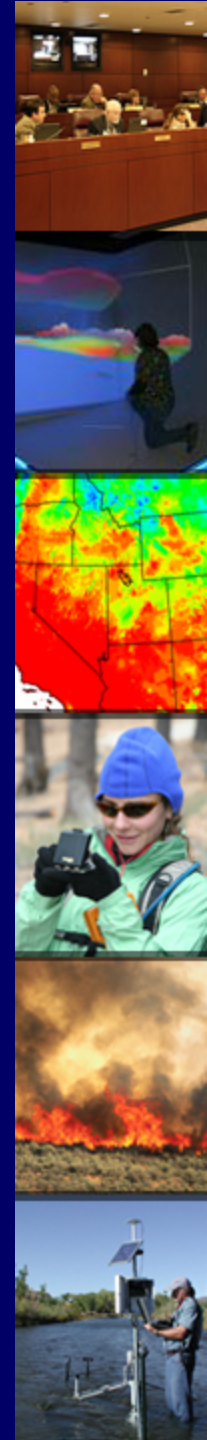
Links with other components

- Cyberinfrastructure
    - Link to data portal and processing software
- Landscape change (land-atmosphere interactions)
    - Paleoclimate modeling
    - Climate modeling
- Water Resources
    - Climate predictions of water resources, their variability, uncertainties, and socio-economic impacts
- Policy
    - *Alternative Future* scenarios (urbanization); socio-economic aspects of future water supply
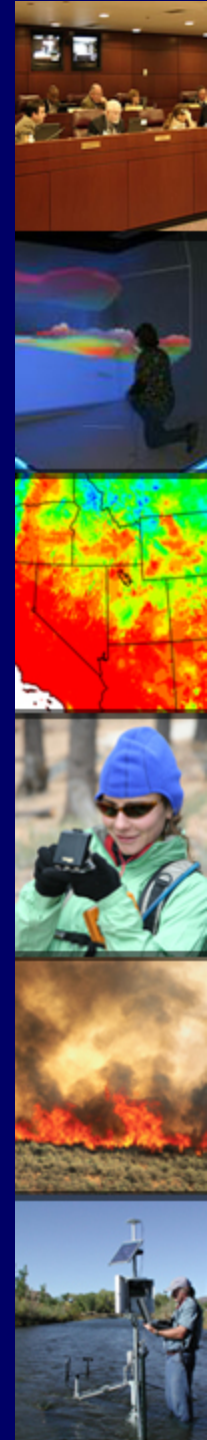- Education – Graduate students, post doctoral fellows

Climate modeling
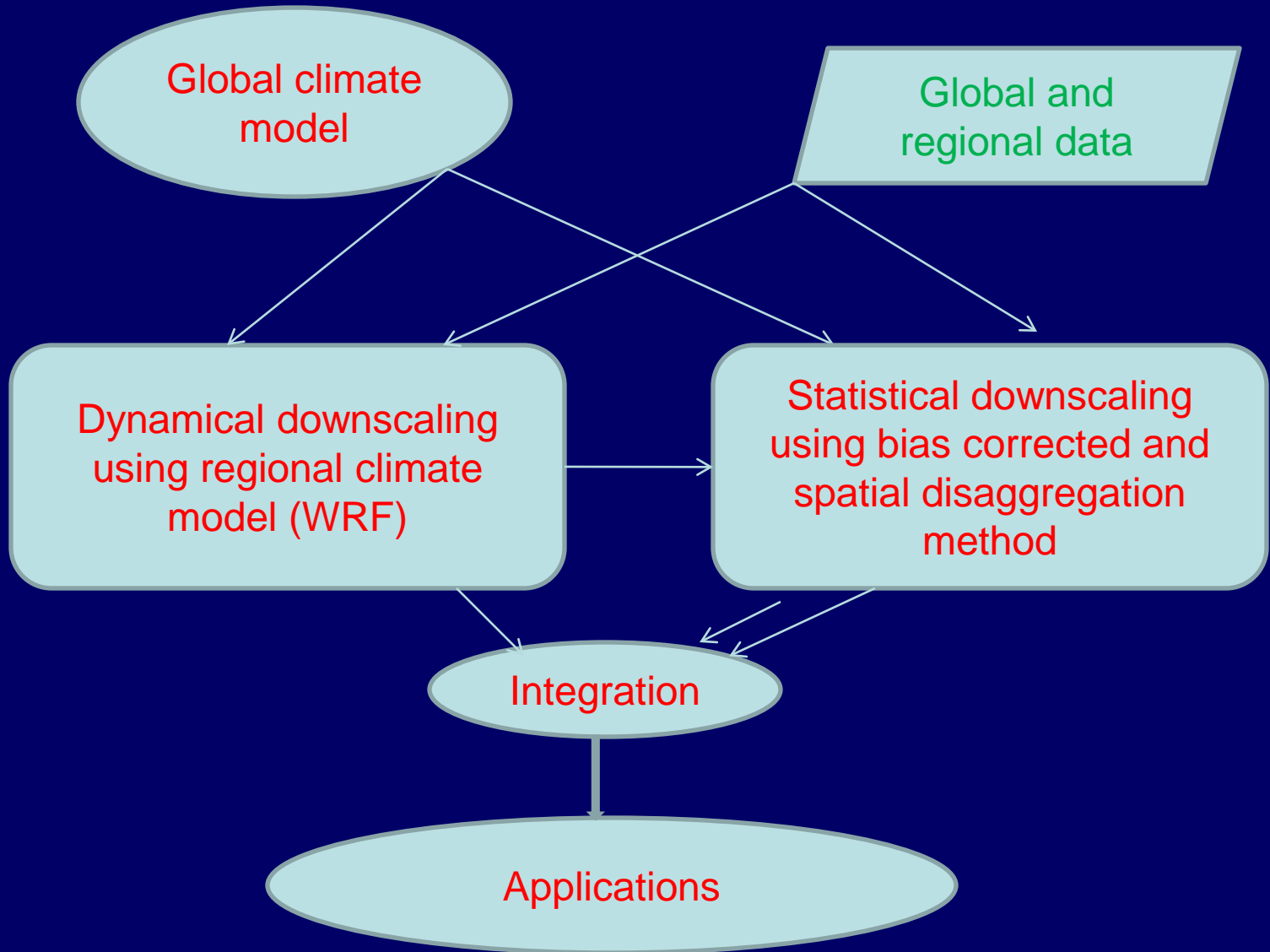
# Regional climate modeling Dynamical downscaling

- Use global climate models with horizontal resolution of 100-200 km to drive regional climate models with resolution of 50 km or better.

- Global climate models provide initial and boundary conditions.

- Regional climate models can have multiple inner-nested domains with increasing horizontal resolutions.
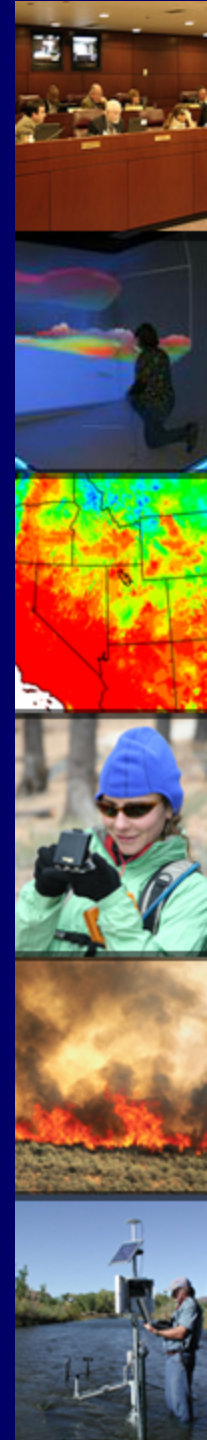
Regional Climate Modeling
Dynamical Downscaling – our study

- This task aims to implement and develop transportable methodologies to improve the applicability of GCMs in climate impact, hydrological, and environmental research.

- Focused on Nevada, but also on a broader region:
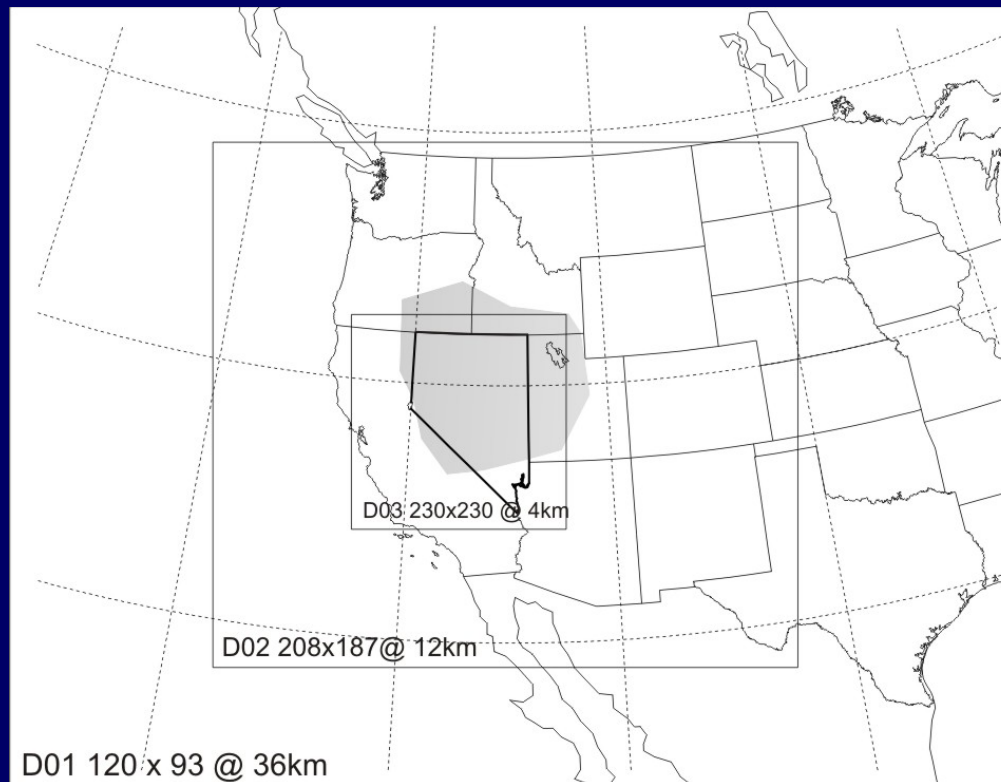
RCM-WRF domains (test version) for dynamical downscaling over the SW North America (at 36 km grid size), the Great Basin (at 12km grid size) and Nevada (at 4km grid size).   Gray shadings represent approximate location of the Great Basin region.

Dynamical downscaling: Regional climate modeling using Weather and Research Forecasting (WRF) model

- PLAN:

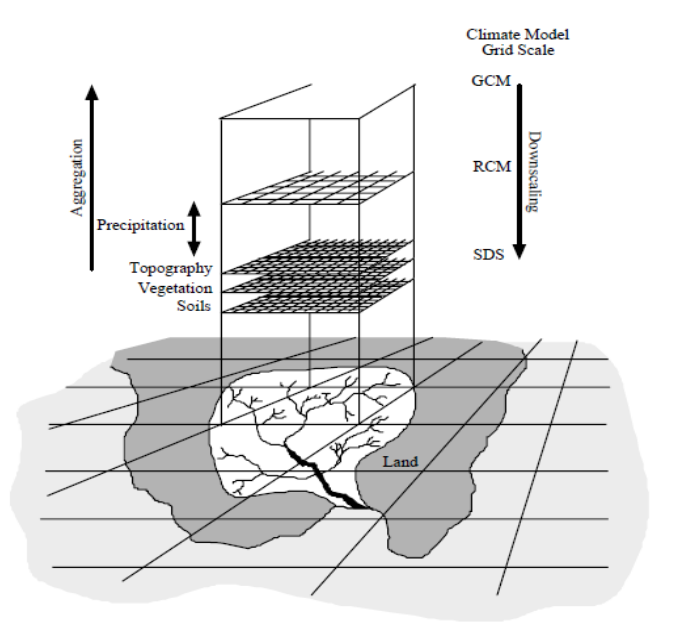| Scenario	1970s	1980s	1990s	2000s	2010s	2020s	2030s	2040s	2050s	2060s	2070s	2080s	2090s
NCEP	■	■	■	■									
CCSM-A1B	■	■	■	■	■			■	■			■	■
CCSM-A2				■	■			■	■			■	■
CCSM-B2				■	■			■				■	■

Schematic of the integration periods (shaded boxes) for different scenarios for the RCM downscaling approach. All simulations total 250 years.

- Bulk of the computation would take about 6 months cpu time
- Hourly and 3 hourly RCM output data.
- Some data archiving issues: Available storage space 150T but need about 300TB.
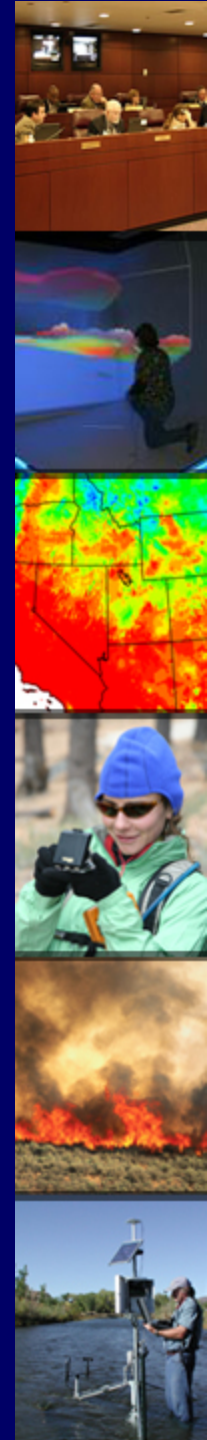
Overview of Statistical Downscaling (SDS)

Conceptual GCM to SDS model.

Statistical downscaling offers a method to 'bridge the gap' between GCM and local/regional impacts (e.g. hydrology, growing degree days)

- Resolution of GCMs is 100-500km while regional climate impact studies require resolutions of <50km (e.g. basin-scale) (12)

- SDS seeks to generate statistical relationships between sets of predictors that are well-represented in the GCM (e.g. 1000-500mb thickness, 500mb geopotential) and predictands (often surface temperature and precipitation) (13)

  - Many techniques have been developed and applied in North America, Europe, South America, Asia, and Africa

Statistical downscaling:
## Bias correction and spatial disaggregation method

- Large scale GCMs carry inherent bias which will interfere with smaller scale climate signals (magnitude and statistical distribution).

- Correction of GCM bias will yield improved results and will 'train' GCM to follow observational distribution

- Method utilizes CDF transform to map distribution of modeled data to observational dataset

- Developed by Climate Impacts Group (CIG) at Univ. Washington, used with success in Pacific Northwest and Eastern U.S.
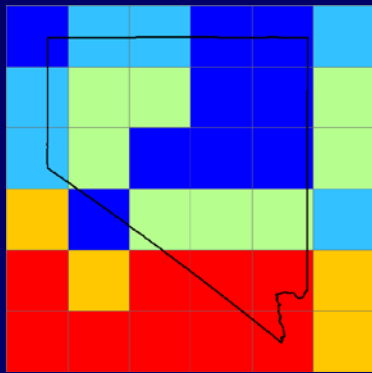
1. Aggregate 4km PRISM observations (Obs) to model grid size (140km)

Empirical CDF
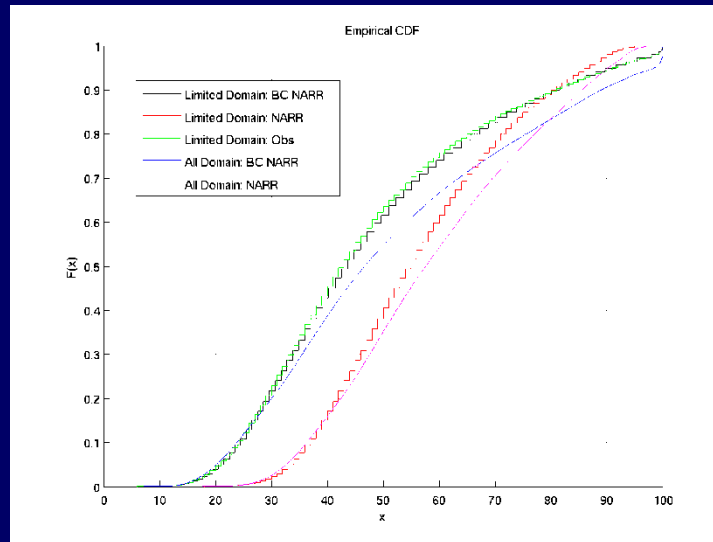
2. Perform CDF transform to correct model bias at model scale (note how BC NARR approaches Obs. (NARR is 'type' of GCM))
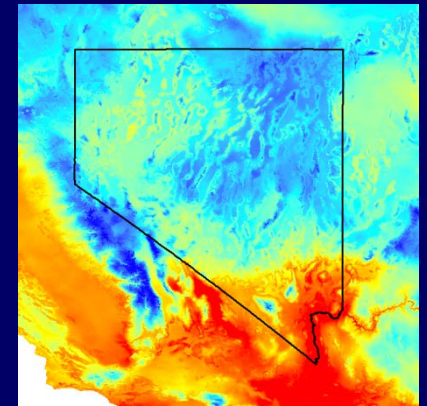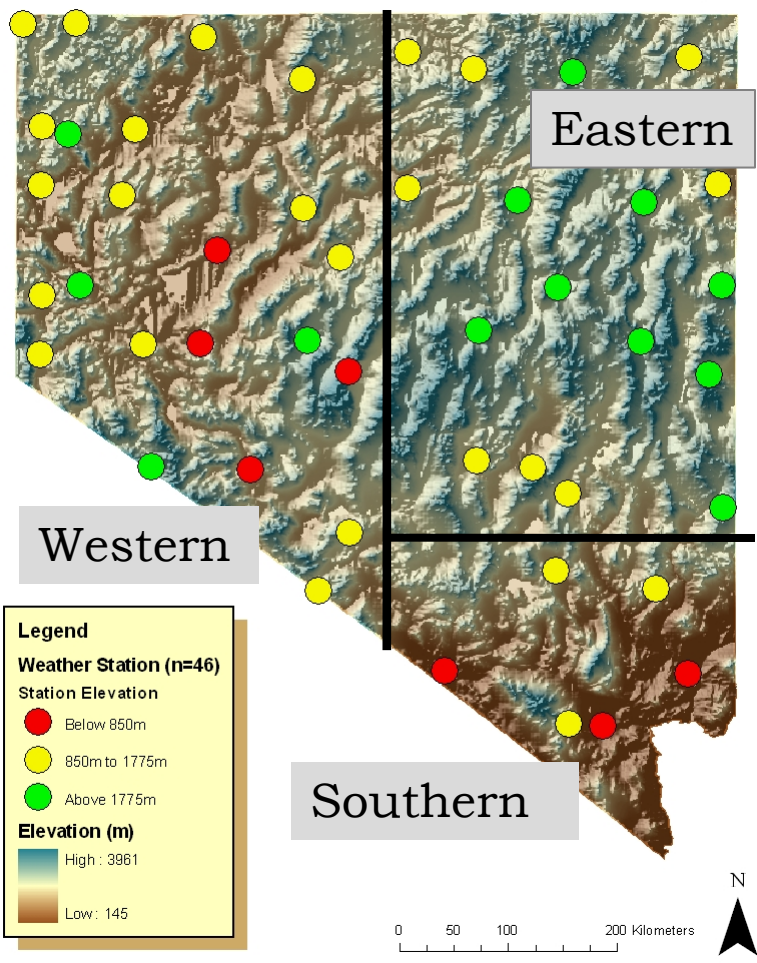

3. Calculate perturbation factors (Diff. of mean ag. Obs and non ag. Obs) and add to future climate model output). Yields 4km (native PRISM grid) resolution results

Nevada Downscaling Station Locations

Nevada Weather Stations Used for Downscaling

Eastern

Western

Southern

Legend
Weather Station (n=46)
Station Elevation
● Below 850m
● 850m to 1775m
● Above 1775m
Elevation (m)
High : 3961
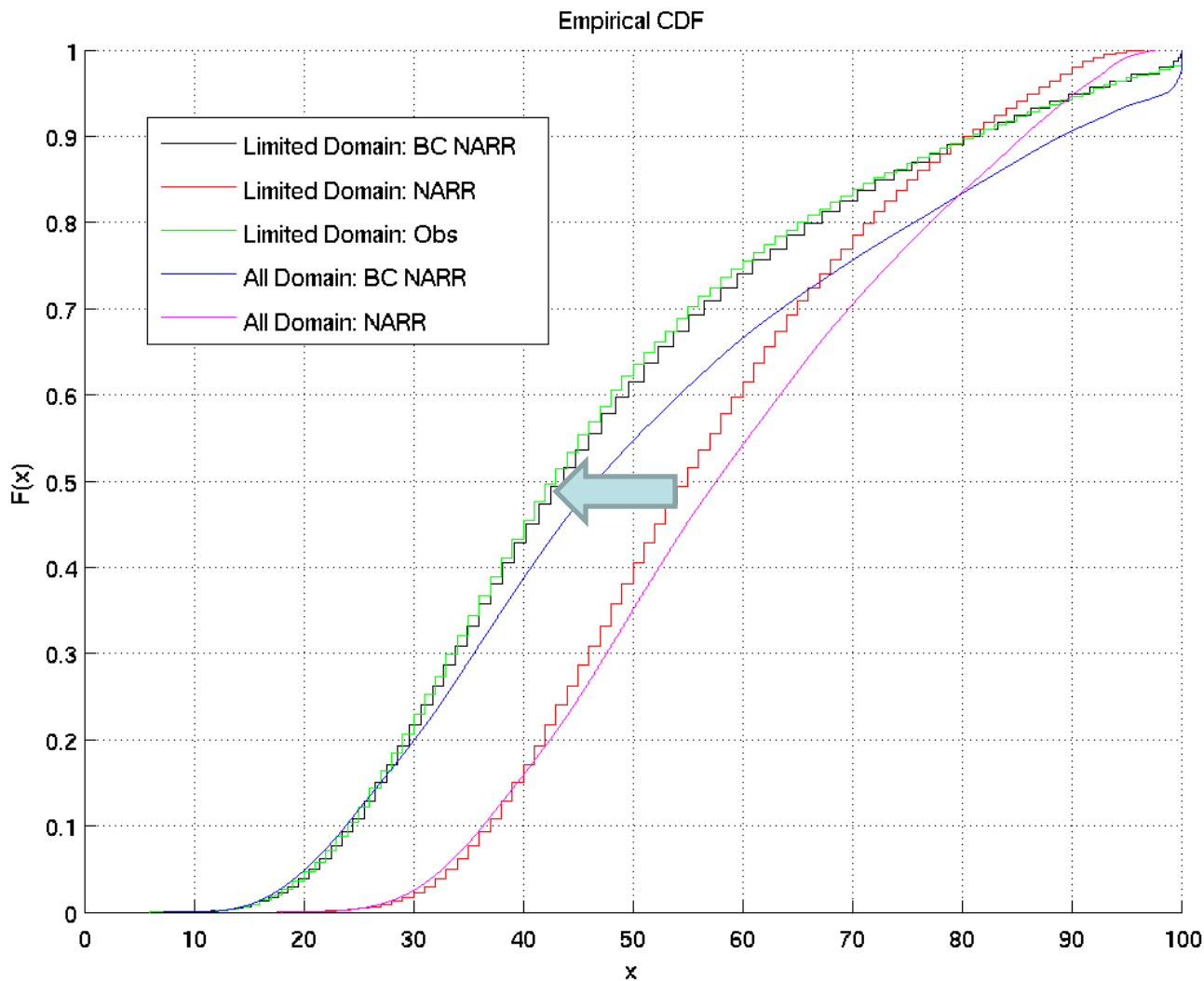Low : 145

0   50   100   200 Kilometers

N

- Note highly complex 'basin and range' topography.
- Four sample stations shown, encompassing range of elevation
- Three precipitation regimes in Nevada (2)
  - Western: Landfalling Pacific cyclones, winter max, high orographic influence (20:1)
  - Eastern: Continental cyclongenesis with advection of Pacific moisture, spring max, less orographic enhancement (2:1)
  - Southern: North American Monsoon influence, summer max, high precipitation spatial and temporal variability
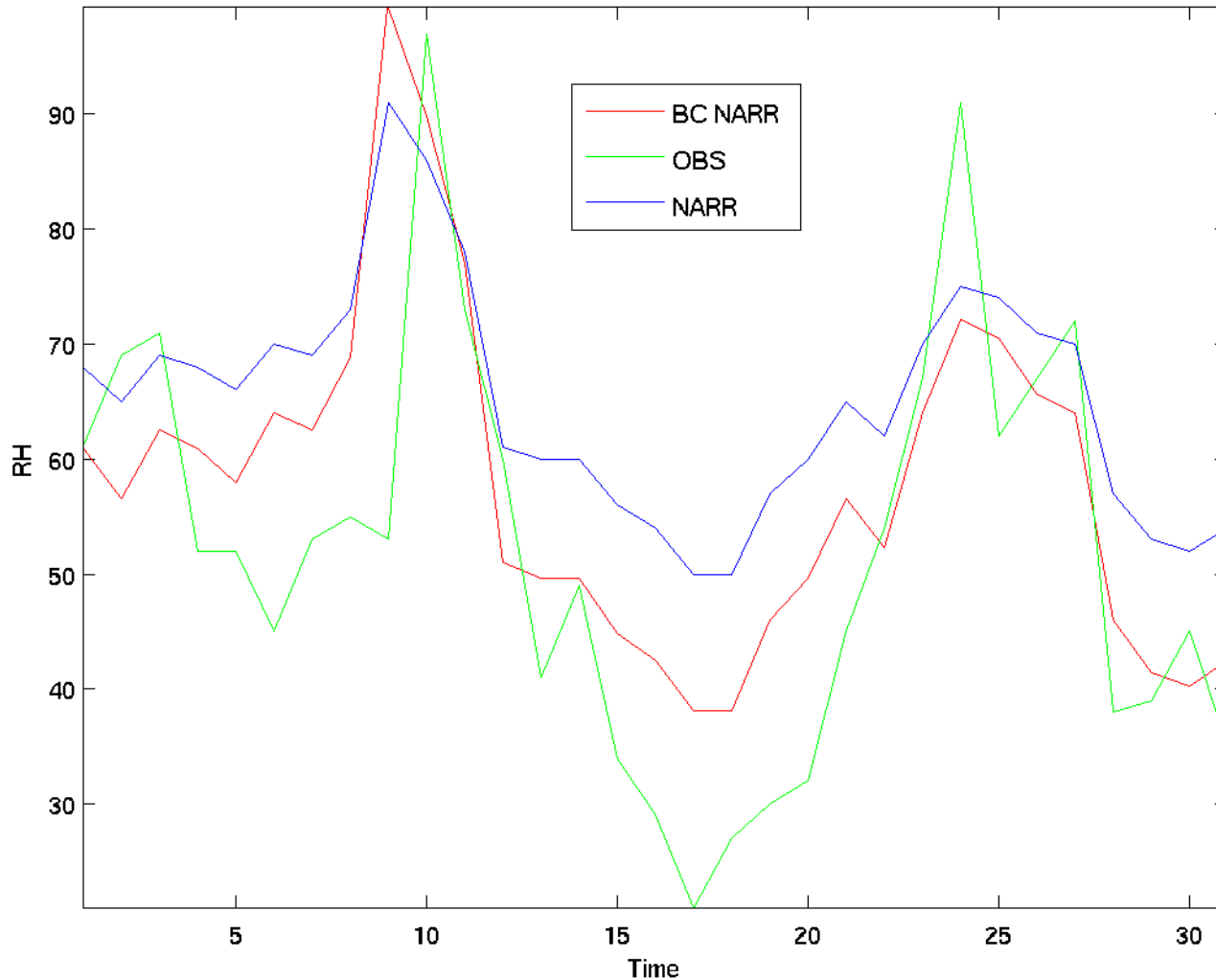
Example of CDF Downscaling

Empirical CDF

Legend:
- Limited Domain: BC NARR
- Limited Domain: NARR
- Limited Domain: Obs
- All Domain: BC NARR
- All Domain: NARR

- Note how bias-corrected "BC" NARR data approaches OBS for both limited and full domain
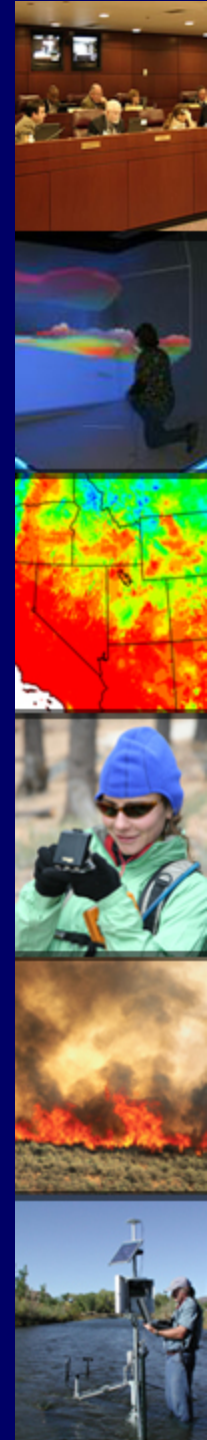- Significant improvement overall, especially in the case of extremes.

CDF Downscaling Example Cont'd

- Notice how after bias correction, the modeled dataset (NARR) is fit better to the observations in both overall fitting and for extremes

Next Steps...

- Complete downscaling of CCSM, CSIRO, ECHAM5 temperature (min and max) and precipitation
- Spatial downscaling to stations
- Run downscaled results in hydro model and input results into urban model
- Comparisons of downscaling results
  - Stations to Grids
  - Intercomparisons of models (CCSM3, CSIRO, ECHAM5) and scenarios (A1B, A2, B1, committed)
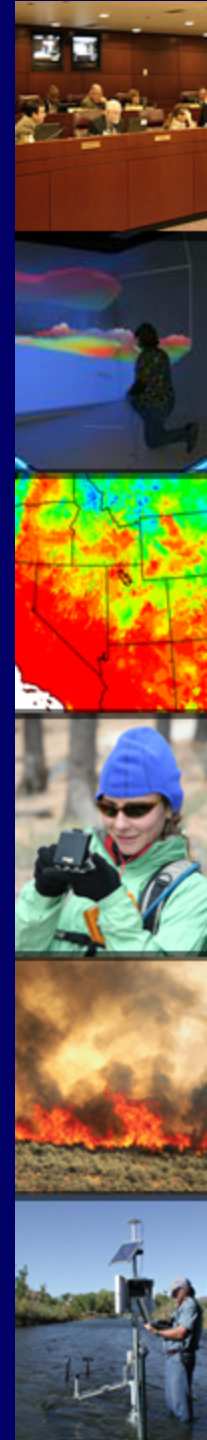
Products

- 4km Min, Max temperature and Precipitation for 3 GCMs using A1B, A2, and B1 scenarios

- Results will be summarized in 10-year increments (2060-2069, 2090-2099, etc.)

- Data will be available in ASCII format to easily be incorporated into GIS and various other models

- First downscaling results to be submitted Summer 2010, results of climate-hydro-urban modeling project hopefully submitted by Fall 2010
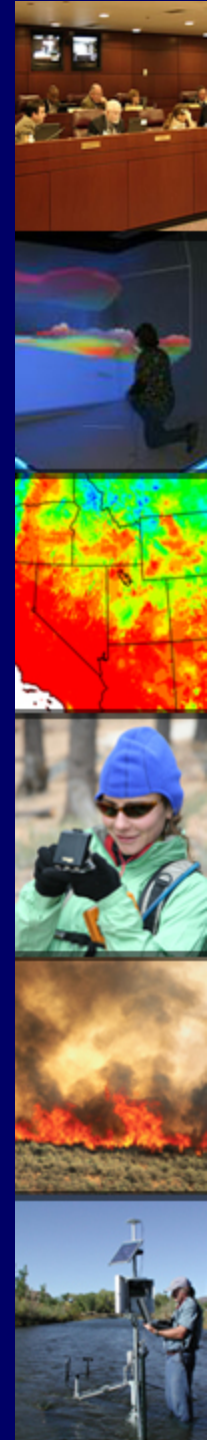
Future steps

- Climate model results as input to hydrological models
- CCSM3 optimum parameterizations
- Use of CCSM4 to be released in April 2010
- Ensemble approach to regional climate predictions
- Extreme weather events
- Statistical downscaling applied to hydrological modeling

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