Feb 2nd, 9:30 AM - 3:30 PM

Research poster: Climate prediction downscaling of temperature and precipitation in the Great Basin region

Ramesh Vellore
Desert Research Institute

Benjamin J. Hatchett
Desert Research Institute; University of Nevada Reno, Benjamin.Hatchett@dri.edu

Darko Koracin
Desert Research Institute, Darko.Koracin@dri.edu

Climate prediction downscaling of temperature and precipitation in the Great Basin region

Ramesh Vellore[1], Benjamin J. Hatchett[1,2], and Darko Koracin[1]

[1] Desert Research Institute (DRI) Reno, Nevada, [2] Graduate Program in Atmospheric Sciences, University of Nevada, Reno

ABSTRACT

The primary objective of this study is to investigate the model biases in three global climate model (GCM; NCAR-CCSM3, ECHAM5, and CSIRO-Mk3.5) outputs and their ensembles under designated Intergovernmental Panel on Climate Change (IPCC) climate change scenarios to assess future hydrological resources and their variability, uncertainties, and socio-economic impact in the semi-arid and mountainous terrain of Nevada as well as the entire southwest U.S. region. The study addresses downscaling methodology for the surface variables (2-m air temperature and precipitation) from GCM horizontal grid resolutions (100 km or more) to regional scales (10 km or less) appropriate for hydrologic impact studies.

Preliminary hindcast analysis for a 50-year period (1950-2000) indicated that the precipitation rates extracted from the GCMs at 46 individual stations in Nevada show correct seasonal trends, but the monthly mean precipitation rates are significantly overestimated, especially in the Humboldt River watershed region (an area of 44030 km2) of Nevada. The areal mean precipitation rate is considerably biased by about 5 mm day-1 as compared to observations (Western Regional Climate Center, DRI; WRCC), and National Climate Data Center (NCDC) and Parameter-elevation Regressions on Independent Slopes Model (PRISM) climate data sets. The daily mean surface air temperature from the GCMs and a regional climate model (RCM) using Weather Research and Forecasting (WRF) forced by the CCSM3 outputs is generally under-predicted, with root-mean-square errors as large as 6K on an annual scale.

The present study employs bias correction and spatial disaggregation (BCSD) models to improve representation of synoptic-scale seasonal and extreme events at local and regional scales. Recognizing the non-stationarity in the climatic and hydrologic processes, an ensemble approach is used to better represent the range of possible outcomes under different IPCC greenhouse gas emissions scenarios. The study also will contribute to further improvements of the convective and microphysical parameterizations in the Weather Research Forecasting regional climate model (WRF-RCM).

MOTIVATION

1.**Changes** in climate in the arid west affects: water resource supply and demand, energy demand, and the landscape ecology
2. **Understanding** these changes is critically important to **manage and plan** for future hydrological, urban, and ecological demand.
3. Climatic change is manifested both **culturally and naturally**, a major natural effect is on vegetation (Wharton et al. 1990).
5. Nevada and the Great Basin have been identified as a **highly sensitive** region to climatic change, (Maggs 1989). Nevada can serve an important role in validating GCM predictions as well as illuminate shortcomings in the GCM parameterization schemes.
6. **Downscaling** of GCMs via statistical and dynamical methods in Nevada is necessary given the highly complex terrain and multitude of seasonally-dependent climatic regimes which are not accurately captured by coarse resolution GCMs (Figure 1).
7. Future climate predictions can be **implemented** in hydrological, ecological, and social models to **mitigate** the effects of change.

Figure 1: Nevada's Great Basin

Nevada, which lies within the Great Basin, is composed of complex transverse N-S oriented mountain ranges and alluvial basins. The region is characterized by three dominant precipitation regimes: I: Warm, moist Pacific (winter max), II: Cold, dry continental (spring max), and III: Warm, moist Gulf (summer max). The Great Basin undergoes wide diurnal and seasonal temperature ranges, and as a result has widely varying growing seasons. These factors, coupled with orographic influences generate highly diverse vegetation within a close proximity Shifts in the locations of vegetative communities can be triggered by slight alterations in climatic patterns or disturbances.

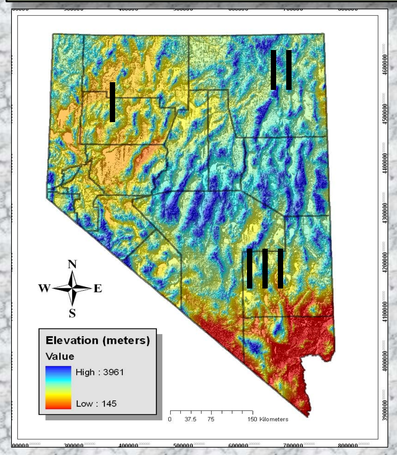
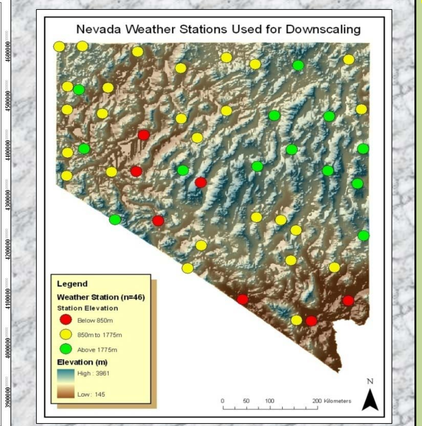


Figure 2

46 Weather stations will be used in the downscaling process. They will serve as both verification sites and be integrated into the dynamical model to provide observational data. PRISM data will also be downscaled.



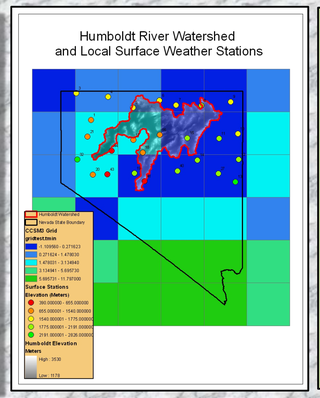


Figure 4

The large scale of GCM grids is obviously inadequate to provide accurate regional and local predictions of temperature and precipitation, even for large watersheds such as the Humboldt River Watershed. Downscaling is the necessary step to bridge the gap. Downscaling can be applied to either surface stations (shown) or to continuous raster datasets such as PRISM.

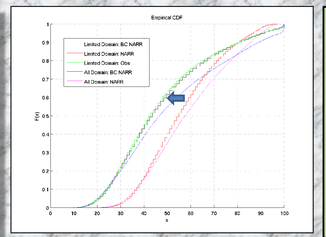
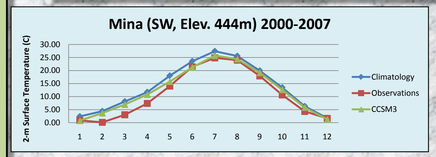
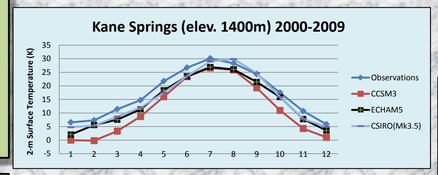


Figure 5 (left)

An example (courtesy J. Abatzoglou) of bias correction via the CDF mapping technique is presented. The bias correction scheme produces improvements in overall fit of the data, especially in the extremes.

PRELIMINARY RESULTS AND OBSERVATIONS





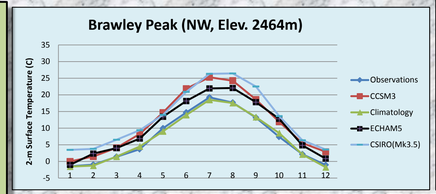


Figure 6 (left)

While the models correctly predict seasonal trends at three example stations, biases between 2-6 C exist. These biases must be corrected in the first step of the downscaling.

Figure 7 (below)

The simple bias correction method is successful at reducing the difference between the Observed Mean and Corrected Model Mean to 0C only in January. If this difference does not converge closer to 0 compared to the difference between the Observed Mean and Uncorrected Model Mean, the method has not reduced the bias. This shows that a different method must be chosen.

Figure 8 (below)

Multi-model predictions of monthly areal mean precipitation rates. IPCC experiment: 20thcentury Climate Change Experiment. GCM archived data is interpolated at 46 locations spanning the entire state of Nevada and areal mean is computed using Delaunay triangulation procedure.

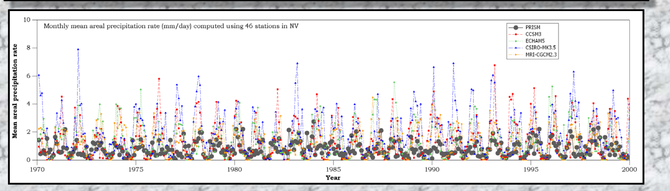
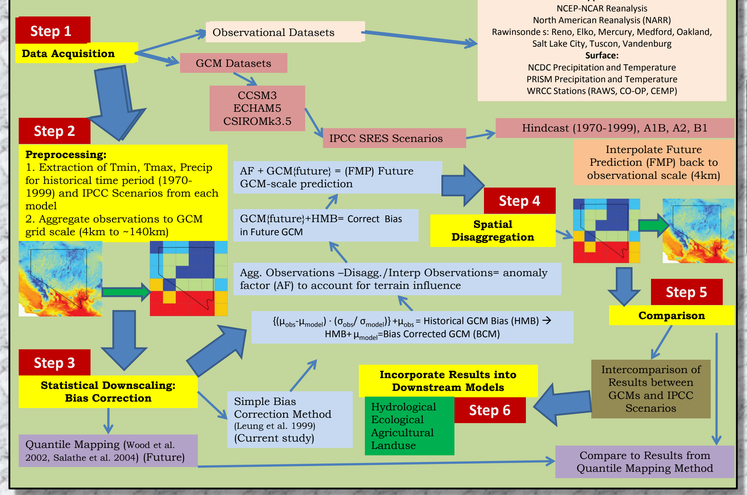


Figure 3:
The Flow and Methods of Statistical Downscaling: From Data Acquisition to Climate Impact Modeling



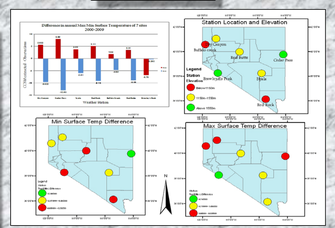


Figure 9 (above)

Differences exist between CCSM3 data and several surface stations spanning the study area. Similar differences (not shown) exist between observations and other GCM model outputs.

CONLCUSIONS AND CONTINUING WORK

- Complete automation steps to enable rapid completion of downscaling throughout Nevada and Great Basin
- Is there a better way to account for terrain and synoptic forcing in statistical downscaling process ?
- Simple bias correction scheme is only partially successful. CDF-mapping method will be utilized instead.
- Downscale at least 3 models, for 6 10-year periods under 3 emissions scenarios
- Complete dynamical downscaling process, then compare results.
- Can we use statistical methods to bias correct GCM-input to dynamical downscaling effectively?

REFERENCES

1. Maggs, W.W. 1989. Warming will alter water resources. EOS 70:67-74.
2. Leung, R. A.F. Hamlet, D.P. Lettenmaier, A. Kumar. 1999. Simulations of the ENSO Hydroclimate Signals in the Pacific Northwest Columbia River Basin. BAMS 80(11): 2313-2329.
3. Salathe, E. 2004. Methods for selecting and downscaling simulations of future global climate with application to hydrologic modeling. *Int. Jour. Climat.*, **25**, 419-436.
4. Wharton, R.A., et al. 1990. The North American Great Basin: A Sensitive Indicator of Climatic Change. In: Plant Biology of the Basin and Range. Osmond, C.B. Pitelka, L.F. and G.M. Hidy eds. Springer-Verlag.
5. Wood, A.W., E.P. Maurer, A. Kumar, D.P. Lettenmaier. Long-range experimental hydrologic forecasting for the eastern United States. Jour. Geophy. Res. 107(20):4429.

ACKNOWLEDGEMENTS

Funding for this project has been provided by the National Science Foundation Grant NSF-08-500,"**Nevada Infrastructure for Climate Change Science, Education, and Outreach**". The following individuals have also contributed to this project: Travis McCord, John Mejia, Lin-Lin Pan, (DRI) and Michele Breckner of the Western Nevada Climate Center.