NARCCAP Model Validation for the Southeast United States

E D Kabela 1,2 and G J Carbone 1

1 University of South Carolina, Dept. of Geography, Columbia, SC 29208
2 Oak Ridge National Laboratory, Global Nuclear Security Technology Div., Oak Ridge, TN 37831

Introduction

Global climate models (GCMs) provide most projections of future climate change. But their coarse resolutions limit their use in assessing regional climate change impacts on water resources, environmental quality, forest management, power plant operations, and many other fields. Such assessment requires translating global model output to more local scales. This research investigates dynamically downscaled regional climate model (RCM) output from the North American Regional Climate Change Assessment Program (NARCCAP) in the Southeast United States. Analysis includes assessments of GCM and RCM performance and skill in the region during a historical reference period (1970-1999), with explanations of sources and magnitude of individual model bias.

Three fundamental questions structure the research:

- How skillful are dynamically downscaled models in simulating minimum and maximum temperature and mean precipitation in a historical reference period (1970-1999) for the Southeast United States?
- Does downscaling improve projections at local scales? Is “value added” in downsampling?
- What are the magnitude of biases for each NARCCAP member (and variable) and what is the potential source of the bias?

Data and Methods

- 12km grid-resolved dataset from 1970 to 1999 from the University of Washington (Maurer et al., 2002).
- 50km RCM historical (1970-1999) output from NARCCAP (Mearns et al., 2009).
- 32km North American Regional Reanalysis (Mesinger et al., 2006).
- Observed and RCM data remapped using nearest-neighbor algorithm from native coordinates and projections to WGC84 projection with 50km resolution.
- Daily grid point values extracted if within 0.5° of Alabama, Georgia, Mississippi, Southeast United States. Analysis includes assessments of GCM and RCM performance and skill in the region during a historical reference period (1970-1999), with explanations of sources and magnitude of individual model bias.

Four methods used to quantify model skill:

- Using the Root Mean Square Error (RMSE) to calculate the average of the squares of the errors.
- Mean Absolute Error (MAE) to calculate the average of the absolute errors.
- Willmott's index of agreement (b) to measure the degree of agreement between observed and modeled values.
- Mean precipitation model skill (regardless of sub-region) highly dependent on the magnitude of biases for each model.

Results – Value Added

- Root Mean Square Error (RMSE) = \[ \sqrt{\frac{\sum_{i=1}^{n} (y_i - \bar{y})^2}{n}} \]
- Mean Absolute Error (MAE) = \[ \frac{1}{n} \sum_{i=1}^{n} |y_i - \bar{y}| \]

Results – Model Bias

- Willmott's index of agreement (b) = \[ 1 - \frac{\sum_{i=1}^{n} (y_i - \bar{y})^2}{\sum_{i=1}^{n} (y_i - \bar{y_{\text{obs}}})^2} \]
- Mean precipitation model skill (regardless of sub-region) highly dependent on the magnitude of biases for each model.

Conclusions

- All models relatively skillful in reproducing daily minimum temperature trends for both sub-regions, less overall skill observed for maximum temperature trends.
- WRFG RCMs, ECP2-GFDL, and GFDL-timeslice show degradation in skill during summer months while RCM3-GFDL and ECP2-GFDL exhibit degradation in winter (min temperature, RCM3- and ECP2-GFDL exhibit very low skill across all months (max temperature). Most consistently skillful models across all months are RCM3- and CRCM-CGCM3, and NARCCAP.
- GFDL-timeslice has higher skill and more value added than either RCM run with GFDL-CCSM.
- Mean precipitation model skill (regardless of sub-region) highly dependent on skill metric.
- Value added by individual ensemble members highly dependent on skill metric and month. For temperature, RCMs driven by the CCSM GCM added most value. Those driven by GFDL added least skill. For precipitation, WRFG adds positive value for least nine months out of year. Models adding least value were WRFG-CGCM and GFDL-timeslice.
- Comparison of climatological variables at micro-, meso-, and synoptic-scales revealed systematic biases for those models which exhibited less skill.

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References


Contact Information: Erik D. Kabela, kabelaed@ornl.gov, 1 Bethly Valley Road, Oak Ridge, TN 37831