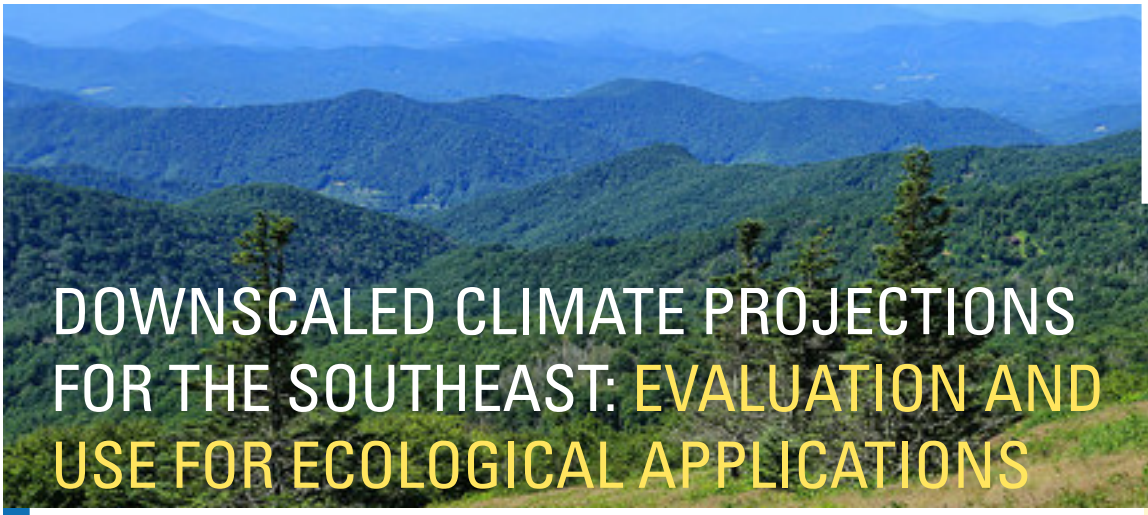


DEPARTMENT of the INTERIOR
SE CLIMATE SCIENCE CENTER

DOWNSCALED CLIMATE PROJECTIONS FOR THE SOUTHEAST: EVALUATION AND USE FOR ECOLOGICAL APPLICATIONS

SE CSC FACT SHEET 2015-01

This fact sheet provides highlights from a comprehensive U.S. Geological Survey report that evaluates six widely used downscaled climate projections covering the southeastern United States and recommends best practices for use of downscaled datasets for ecological modeling and decision-making.

THE CHALLENGE

Many scientists and decision-makers want to use downscaled climate projections to inform decisions about conservation, resource management, and other environmental issues. Choosing the most relevant downscaled datasets for a specific application from among the many available data products is important but can be difficult.

FINDINGS

> No single downscaled climate dataset best represents all aspects of temperature and precipitation across the entire report domain.
> Complex topography and elevation of the Southern Appalachian Mountains are not well represented in these downscaled datasets, causing challenges with projections of temperature and precipitation in this region.
> Precipitation associated with hurricanes is not well simulated in Global Climate Models (GCMs), leading to errors in downscaled datasets in precipitation variability during Atlantic hurricane season.
> All datasets inherit errors from the GCMs driving the downscaling. Datasets created with dynamic downscaling techniques benefit from bias correction prior to use in ecological modeling.
> Specific strengths and weaknesses for the US Southeast are highlighted on the following pages.

RECOMMENDATIONS FOR SELECTING AND USING DOWNSCALED CLIMATE PROJECTIONS

> Consult a climatologist familiar with climate models and downscaling.
> Take advantage of expert knowledge to choose appropriate downscaled climate projections for ecological modeling.
> Use more than one downscaled dataset; ensemble projections can offset weaknesses of individual datasets.
> If it is only feasible to use one downscaled dataset, consider the best possible one for all sensitivities.
> Prioritize the downscaled dataset that best represents the aspect of climate that has the greatest influence on species or ecosystem of interest.

COMPARING DOWNSCALED CLIMATE PROJECTIONS IN THE SOUTHEAST

Six widely used, peer-reviewed, and publicly available downscaled datasets, representing a range of characteristics and downscaling techniques, were evaluated. Datasets were aggregated as necessary for evaluation at the same scales, periods, and domains:

> Common spatial and temporal resolution (50km and monthly)
> Common parameters (temperature and precipitation) – means, variability, and extremes
> Historical time period (1971-1999)

Two climate variables – monthly average temperature and precipitation – were compared to observational data from PRISM (Parameter-elevation Regression on Independent Slopes Model).

DYNAMICALLY DOWNSCALED*

CLAREnCE10

(COAPS Land-Atmosphere Regional Ensemble Climate Change Experiment)
– Vasu Misra, Center for Ocean Atmospheric Prediction Studies at Florida State University. Stefanova et al., 2012, A proxy for high-resolution regional reanalysis for the Southeast United States: assessment of precipitation variability in dynamically downscaled reanalyses: Clim Dyn (2012) 38:2449-2466, doi:10.1007/s00382-011-1230-y.

STRENGTHS

> Lowest error among dynamic datasets for Florida, Georgia, Alabama, and the Carolinas for monthly mean temperatures.

> Best representation of the annual cycle of mean monthly precipitation in the coastal Carolinas among dynamic datasets.

WEAKNESSES

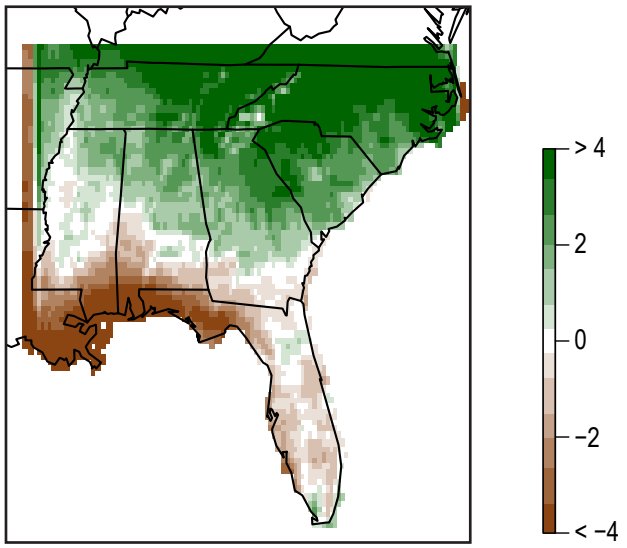
> Raw data retain the biases of the GCM, so bias correction is needed, or it is important to focus on projected change.

> Data not available in the northern and western portions of the Southeast.

> Tendency to overestimate average monthly precipitation in summer months in the northern, and to underestimate it in southern, areas of the Southeast.

EXAMPLE ANALYSIS OF CLAREnCE10 DATASET

BIAS IN JULY AVERAGE PRECIPITATION (mm/day)



DYNAMICALLY DOWNSCALED*

USGS DDRC

(USGS Dynamical Downscaled Regional Climate)
– Steven Hostetler, U.S. Geological Survey/Oregon State University. Hostetler et al., 2011, Dynamically downscaled climate simulations over North America: Methods, evaluation, and supporting documentation for users: USGS Open File Report 2011-1238.

STRENGTHS

> Best captures the annual cycle for monthly average temperatures and the inter-annual variability among dynamic datasets (together with NARCCAP).

> Lowest error among dynamic datasets for monthly mean precipitation for south Florida through the Southern Appalachians.

> Best representation of the annual cycle of monthly mean precipitation for Florida, southern Georgia, and southern Alabama.

WEAKNESSES

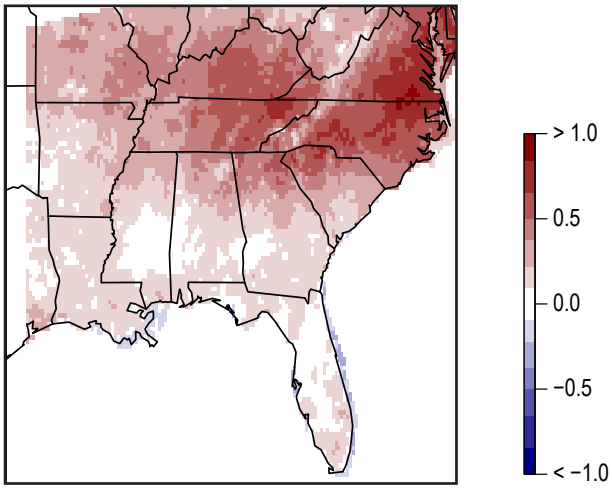
> Raw data retain the biases of the GCM, so bias correction is needed, or it is important to focus on projected change.

> Tendency to underestimate the inter-annual variability of precipitation, i.e., the frequency of extreme precipitation events, in August through October.

> Tendency to overestimate the inter-annual variability of temperatures, i.e., the frequency of extreme temperature events, in February through April.

EXAMPLE ANALYSIS OF USGS DDRC DATASET

STANDARD DEVIATION DIFFERENCE FOR MARCH AVERAGE TEMPERATURE (°C)



DEFINITIONS

A Global Climate Model (GCM) is a numerical model that uses physical laws and relationships to simulate the earth's climate.

Downscaling is a translation of information from GCMs to finer spatial resolution.

Dynamic Downscaling uses high-resolution Limited Area Models, which are based on the same physical processes but nested at a higher resolution within a GCM.

Statistical Downscaling uses techniques that develop empirical relationships between climate variables observed at regional/local scales and GCM output.

DYNAMICALLY DOWNSCALED *

NARCCAP

(North American Regional Climate Change Assessment Program)
– Linda Mearns, National Center for Atmospheric Research, National Oceanic and Atmospheric Administration, National Science Foundation, U.S. Environmental Protection Agency, U.S. Department of Energy. Mearns et al., 2009, A regional climate change assessment program for North America: Eos Trans. AGU, 90(36), 311-312, doi:10.1029/2009EO360002.

STRENGTHS

> Best captures the annual cycle for monthly average temperatures and the inter-annual variability among dynamic datasets (together with USGS DDRC).

> Has the best representation of the annual cycle of mean monthly precipitation in the northwest portion of the Southeast among dynamic datasets.

WEAKNESSES

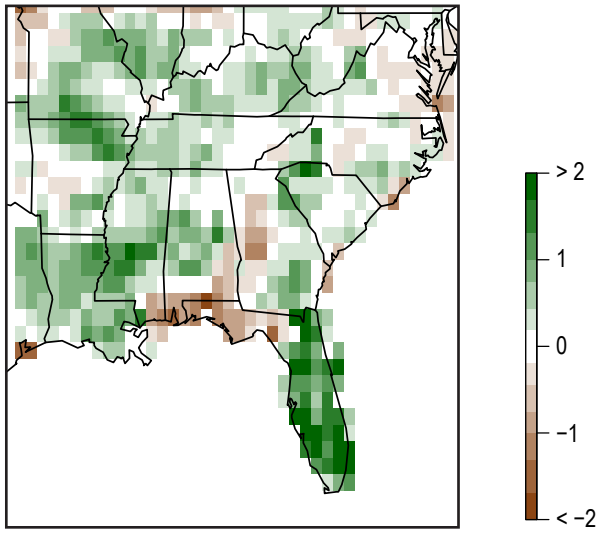
> Raw data retain the biases of the GCM, so bias correction is needed, or it is important to focus on projected change.

> No data available at a resolution finer than 50 km.

> Tendency to overestimate the inter-annual variability of temperature and precipitation in summer in the Southeast.

EXAMPLE ANALYSIS OF NARCCAP DATASET

STANDARD DEVIATION DIFFERENCE FOR JULY AVERAGE PRECIPITATION (mm/day)



STATISTICALLY DOWNSCALED *

BCSD

(Bias Corrected Spatial Disaggregation)
– Edwin Maurer, Santa Clara University/U.S. Department of Energy. Maurer et al., 2007, Fine-resolution climate projections enhance regional climate change impact studies: Eos Trans. AGU 88(47), 504-504 doi:10.1029/2007EO470006.

STRENGTHS

> Lowest error among statistical datasets in representing monthly mean precipitation for northern Gulf Coast and north Florida coast through coastal Carolinas.

> Lowest error among statistical datasets in representing the inter-annual variability of temperatures across most of the southeastern U.S.

WEAKNESSES

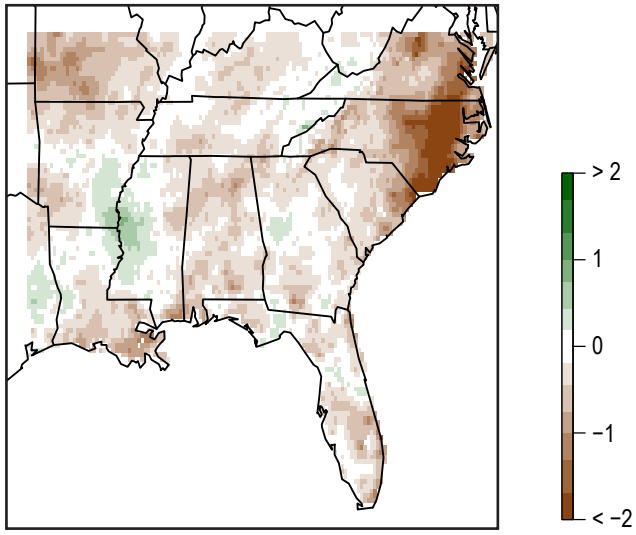
> No daily data are available.

> Dramatically underestimates the frequency of heavy rainfall events in the coastal Carolinas associated with hurricanes.

> Consistent tendency to underestimate the inter-annual variability of precipitation, i.e., to underestimate the frequency of extremes.

EXAMPLE ANALYSIS OF BCSD DATASET

STANDARD DEVIATION DIFFERENCE FOR SEPTEMBER AVERAGE PRECIPITATION (mm/day)



EVALUATION METRICS

Bias is the difference between the mean of a variable predicted by a model and the mean of its observed value.

Standard Deviation Difference is the difference between the standard deviation of a variable predicted by a model and the standard deviation of its observations.

* Detailed characteristics of each downscaled climate dataset are provided on Page 9 of the full report.

STATISTICALLY DOWNSCALED *

CCR

(Center for Climatic Research)

– David Lorenz, Center for Climatic Research, Wisconsin Initiative on Climate Change Impacts. Notaro et al., 2014, Twenty-first-century projections of snowfall and winter severity across central-eastern North America: J. of Climate, 27, 6526-6550. doi:10.1175/JCLI-D-13-00520.1

STRENGTHS

> Lowest error among statistical datasets for monthly mean temperature for most of the southeastern U.S.

> Lowest error among statistical datasets for the inter-annual variability of precipitation in the coastal Carolinas and southern Virginia.

WEAKNESSES

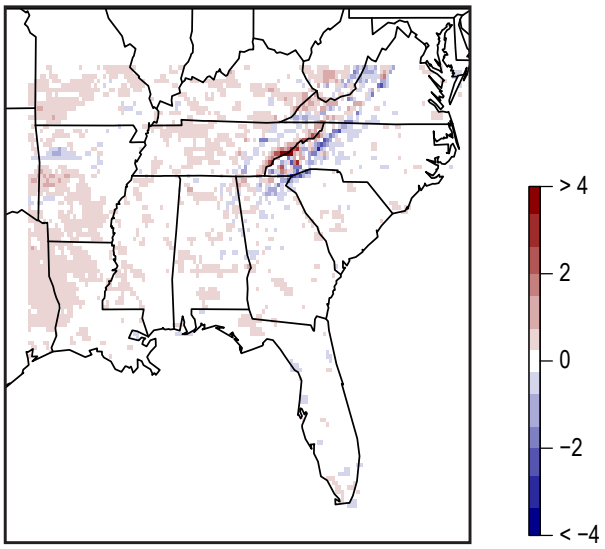
> Consistent tendency to overestimate the inter-annual variability of temperature for February through April.

> Dramatically underestimates the frequency of heavy rainfall events associated with hurricanes in the coastal Carolinas.

> Tendency to overestimate temperatures on the west side and to underestimate them on the east side of the Southern Appalachians.

EXAMPLE ANALYSIS OF CCR DATASET

BIAS IN AUGUST AVERAGE TEMPERATURE (°C)



STATISTICALLY DOWNSCALED *

SERAP

(Southeast Regional Assessment Project)

– Katharine Hayhoe, Texas Technical University. Stoner et al., 2012, An asynchronous regional regression model for statistical downscaling of daily climate variables: Int. J. Climatol. 33(11), 2473-2494, doi:10.1002/joc.3603.

STRENGTHS

> Error for precipitation and temperature is comparable to, but slightly larger than, BCSD and CCR.

> Offers an additional emissions scenario for analysis compared to other downscaled datasets in this report.

WEAKNESSES

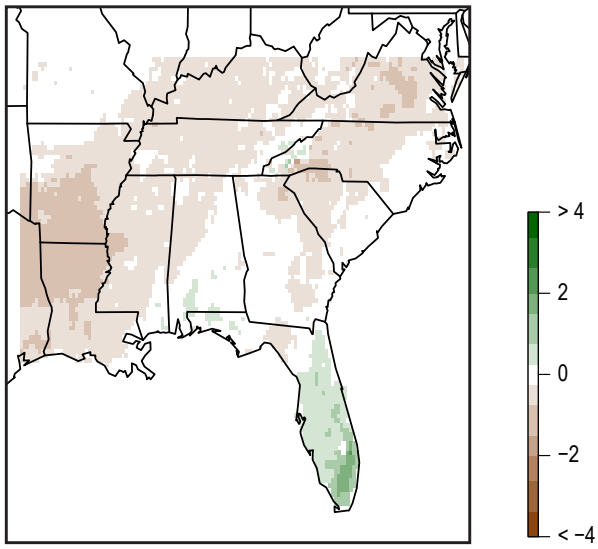
> Tendency to overestimate the inter-annual variability of temperature in February through April and July through September.

> Dramatically underestimates the frequency of heavy rainfall events associated with hurricanes in the coastal Carolinas.

> Tendency to underestimate rainfall from September through November, with the exception of Florida, where rainfall is overestimated.

EXAMPLE ANALYSIS OF SERAP DATASET

BIAS IN OCTOBER AVERAGE PRECIPITATION (mm/day)



RESOURCES

Full report: Wootten, A., K. Smith, R. Boyles, A. Terando, L. Stefanova, V. Misra, T. Smith, D. Blodgett, and F. Semazzi. 2014. Downscaled Climate Projections for the Southeast United States – Evaluation and Use for Ecological Applications. U.S. Geological Survey Open-File Report 2014-1190, 54 pp., http://dx.doi.org/10.3133/ofr20141190.

Downscaled Climate Projections Search Tool and Downscaled Climate Projections Accuracy Viewer: http://globalchange.ncsu.edu/secsc/resources/downscaled-climate-projections-tools/

Authors: Adrienne Wootten and Cari Furiness, Southeast Climate Science Center Fact Sheet 2015-01.

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