Final Project Memorandum
Southeast Climate Science Center Project

1. ADMINISTRATIVE

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Synthesis of climate model downscaling products for the southeastern United States

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013

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2. PUBLIC SUMMARY

Climate change is likely to have many effects on natural ecosystems in the Southeast U.S. While there is information available to conservation managers and ecologists from the global climate models (GCMs), this information is at too coarse a resolution for use in vulnerability assessments and decision making. To better assess how climate change could affect multiple sectors, including ecosystems, climatologists have created several downscaled climate projections that contain information from GCMs translated to regional or local scales. There are a number of techniques that can be used to create downscaled climate projections, and the number of available downscaled climate projections present challenges to users deciding what to use in their applications. The goals of this project were to assess the needs to ecologists in the Southeast U.S. for downscaled climate projections, synthesize the information available, and evaluate a selection of downscaled climate projections based upon the needs of the ecological community in the Southeast. The report produced is a guide which enables the SECSC to address an important strategic goal of providing scientific information and guidance that will enable resource managers and

others in the Landscape Conservation Cooperatives to make science-based climate change adaptation decisions.

3. TECHNICAL SUMMARY

Climate change is likely to impact natural ecosystems in the Southeast via warming temperatures, ocean acidification, sea level rise, and changes to rainfall and evapotranspiration (Ingram et al, 2013). To better assess how these changes could influence multiple sectors, including ecosystems, climatologists have created numerous downscaled climate projections (or downscaled datasets) that contain information translated from global climate models (GCMs) to regional and local scales. The process for creating these downscaled datasets, known as downscaling, can be carried out with a broad range of statistical and numerical modeling techniques. The proliferation of techniques in recent years has led to the production of a large number of downscaled datasets, presenting challenges for scientists and decision makers for assessing the vulnerability of a species or ecosystem to climate change. This project focused on several specific questions that users of downscaled datasets have with regards to how to choose a downscaled dataset (or datasets) to use and their accuracy. 1) How do these downscaled datasets compare to each other? 2) Which variables are available, and are certain downscaled datasets more appropriate for assessing the vulnerability of a particular species? Given the desire to use these downscaled datasets and the lack of comparison between them, the main goal of the project was to synthesize the available information in these downscaled datasets and provide guidance to scientists and natural resource managers with specific interests in ecological modeling and conservation planning related to climate change in the Southeast U.S. At the start of the project, there was no current literature which evaluated downscaled datasets with regards to these applications. There was also no current literature which offered a comparison of the structure of these downscaled datasets with regards to the needs of ecologists in the Southeast U.S. The project itself thus became twofold. First, to synthesize the available literature and information from a subset of downscaled datasets that cover the Southeast U.S. Second, using this synthesis, evaluate this same subset of downscaled datasets to make recommendations regarding the use of the downscaled climate projections and future work needed to make these datasets more useful for ecological modeling and decision making. This project was not intended to evaluate all the projections available, but synthesize the important aspects of downscaled datasets that should be considered when a decision makers or ecologist in the Southeast uses downscaled datasets for their applications. For the first part of the project we performed an extensive literature review (including both climatological and ecological studies) to assess the connections between the downscaled datasets and the needs of the ecological community as a whole. This was augmented by a workshop held in May 2013 in Raleigh, and discussions with a select group of stakeholders from the Landscape Conservation Cooperatives (LCCs) across the Southeast. In addition, to providing added knowledge to the literature review, this furthered the engagement between the climate and ecology communities in the Southeast U.S. For the second aspect of the project, we performed an initial evaluation of six available downscaled datasets for the Southeast U.S. using the knowledge gained from the prior aspect to focus specifically on climate information needs of ecologists in the Southeast. In prior literature, there has been a focus on the specific differences between GCMs, but this evaluation was the first in the Southeast to focus specifically on the differences between the downscaled datasets (and their corresponding downscaling techniques). The result of the project is a report which was written to serve as a guide for the ecological community in the Southeast on the basics of climate modeling, downscaling, and how to choose appropriate downscaled datasets to use based upon their metadata and accuracy. This guide was written with extensive contribution and review by our group of advisors, and the project as a whole furthered the engagement between the climate and ecology communities in the Southeast by connecting climatologists with ecologists and decision makers. The conclusions drawn from the project highlight the need for ecologists and decision makers to consider carefully how downscaled datasets are created in addition to their accuracy for variables of interest. In addition, the conclusions highlight the need from climatologists involved in the development of downscaled datasets to be aware of the needs of the ecological community

and conservation decision makers as new downscaled datasets are created. The conclusions drawn from this project led to four main recommendations to guide the SECSC forward in its efforts to provide scientific information for decision makers and ecologists studying climate change in the Southeast.

4. PURPOSE AND OBJECTIVES

The information synthesis and evaluation of downscaled projections across the Southeast is necessary to provide guidance to users of downscaled projections. This is necessary to provide guidance on the creation and appropriate use of downscaled projections. While this has been considered broadly in the climate science community, it is necessary to consider this with regards to the specific information needs of ecologists and natural resource managers in the Southeast. As such the main objective of the project was to summarize the methods and approaches used to appropriately downscale coarse climate model guidance for use at local scales, identify the metrics most appropriate for evaluation of climate model skill and usability of climate model projections for the ecology and conservation communities, and being a longer-term effort to evaluate a collection of downscaled climate products over the Southeastern United States.

We were able to address the objectives proposed. There were no major differences between what was proposed and the resulting work. The resulting report summarized the strengths and weaknesses of the many kinds of downscaling techniques, including previous literature on the accuracy of such techniques and the influence on the guidance provided by output datasets created with such techniques. The initial evaluation of several downscaled climate projections begins the longer-term evaluation effort proposed. In addition to beginning this effort, the evaluation and associated narrative describes the considerations that an ecologist or natural resource manager should take before choosing a downscaled climate projection to use in their impact assessment or decision.

5. ORGANIZATION AND APPROACH

The work was conducted by a team of scientists from North Carolina State University, Florida State University, the SECSC, and USGS. The following highlights the methodology considered for both aspects of the project (information synthesis and initial evaluation) and the activities associated with each aspect.

Information Synthesis

The information synthesis had two main components to its methodology; the literature review and the end user engagement. For the literature review, we searched through both the climate and ecology literature for studies using downscaled datasets. The climate literature was synthesized to provide the base knowledge on climate modeling and downscaling as well as the state of current knowledge on the accuracy of several kinds of downscaling techniques. The ecology literature related to the use of downscaled datasets was also synthesized for two reasons. First, this allowed for the assessment of current practice in ecology for using downscaled datasets. Second, the ecology literature allowed us to assess some of the current connections / disconnections between the downscaled datasets and ecological applications. As the literature was synthesized, a group of end users was gathered to advise us on aspects of downscaled datasets used in ecology that were not represented in the literature and guide us on appropriate terminology to use in the report prepared at the end of the project.

Fostering engagement and collaboration between the climate and ecology communities in the Southeast was a critical goal of the project. As such, we hosted a workshop which gathered both communities in the Raleigh-Durham-Chapel Hill area. The Regional Climate Variation and Change for Terrestrial Ecosystems Workshop was held in Raleigh in May 2013 and was co-organized with Jared Bowden (UNC Institute for the Environment) and Tanya Spero (U.S. Environmental Protection Agency, Atmospheric Modeling and Analysis Division). The workshop was designed to assist in assessing the primary

variables of interest to the ecological community from the climate models and introduce the ecologists to climate modeling strengths and limitations. The participants discussed how downscaled datasets can be used more effectively, assessed what fundamental knowledge is required by both communities regarding climate sensitivities of species in the Southeast, and discussed how to further engagement between the climate and ecology communities and the Southeast.

Initial Evaluation

This initial evaluation began following the workshop held in May 2013. The information provided from the workshop was used to guide the initial evaluation of downscaled datasets. The evaluation focused primarily on temperature and precipitation in the Southeast, which workshop participants identified as two variables of interest for vulnerability assessments. It was recognized that we could not possibly evaluate all available downscaled datasets with information for the Southeast. Therefore, we selected six downscaled datasets which are publicly available and represented a range of downscaling techniques. These six downscaled datasets included:

- CLAREnCE10 – Center for Ocean Atmosphere Prediction Studies, FSU
- Hostetler – USGS
- NARCCAP – National Center for Atmospheric Research
- CCR – Center for Climatic Research, Wisconsin Initiative on Climate Change Impacts
- BCSD – Bureau of Reclamation
- SERAP – Texas Technical University, USGS

Of these six datasets, the first three were chosen to be representative of dynamic downscaling techniques. The second three were chosen to be representative of statistical downscaling techniques. Given that workshop participants also identified that the variability and extremes of temperature and precipitation were important we chose to evaluate these six downscaled datasets based on the following:

- Bias
- Standard Deviation Difference
- Probability Distribution Functions (PDFs)
- Annual Cycle
- Relative Error

The bias and standard deviation difference were used to assess how each downscaled dataset replicated the means and variance respectively. The PDFs were used to capture how each downscaled dataset replicated the extremes of temperature and precipitation, while the annual cycles were used to show how accurately each downscaled dataset captured the seasonal variations in temperature and precipitation. To summarize the results for the report, the relative error was also calculated. This evaluation was applied across the Southeast U.S. as a whole, and 14 individual sub-regions. The evaluation compared monthly temperature and precipitation data to the PRISM data available from Oregon State University for 1971-2000. Each downscaled dataset and PRISM was also aggregated to a 50 km resolution. This was done since BCSD is only available at a monthly temporal resolution and NARCCAP is only available at a 50 km spatial resolution. The historical time period represents a common time period available between all the downscaled datasets.

6. PROJECT RESULTS

The primary results of the project are summarized below. Text and graphics come primarily from the report published at the conclusion of the project.

Information Synthesis

Metadata refers to the characteristics of each downscaled dataset. For reference, what we have defined as metadata information in this synthesis includes:

- Type of downscaling technique used
- GCMs and emissions scenarios used
- Spatial resolution and domain covered
- Temporal resolution and time period
- Available output variables (temperature,precipitation, etc.).

Our survey is not exhaustive, but includes the most widely used, peer reviewed, and publicly available downscaled datasets. These six downscaled datasets also represent a range of downscaling techniques used to create them. Half of these datasets were created using statistical downscaling techniques, while the remaining three datasets were created using dynamic downscaling approaches.

The type of downscaling technique has an impact on what is available in a downscaled climate projection. For example, dynamic downscaling approaches provide many more variables, but have a limited number of GCMs and emissions scenarios, while statistical approaches provide fewer variables, but can incorporate many more GCMs and emissions scenarios. Table 1 shows the distinct difference between the dynamic techniques and statistical techniques for the number of GCMs and emissions scenarios used. The type of downscaling technique used to create a downscaled dataset also has an influence on the temporal resolution and time periods provided. Figure 1 provides a temporal resolution and time period covered by each of the downscaled projections in this study. The statistical approaches provide daily and monthly information for a near continuous period from 1950-2100. Dynamic approaches provide information at sub-daily timescales, but often provide a historical time slice and a future time slice rather than a continuous time period.

The review of ecological literature, along with the engagement with ecologists, revealed that while there is a desire for fine resolution downscaled datasets (< 4km) from ecologists, this is not currently feasible for all downscaling techniques, nor provided by many of the currently available downscaled datasets. Figure 2 shows a comparison between the desired resolution and the resolution of most currently available downscaled projections. However, the literature review and workshop participants also indicated a need for more fundamental information on the climate sensitivities of species and ecosystems in the Southeast under current climate variability. In addition, the literature review also shows that while the appropriate spatial resolution of downscaled datasets for use in vulnerability assessments has been determined in mountainous regions across the country, it has not been assessed for many regions with less complex topography.

Table 1. Number of GCMs and Emissions Scenarios considered by each downscaled dataset.

Downscaled Dataset	Number of GCMs	Number of Emissions Scenarios
CLAREnCE10	3	1
Hostetler	3	1
NARCCAP	4	1
CCR	10	3
BCSD	18	3
SERAP	12	4

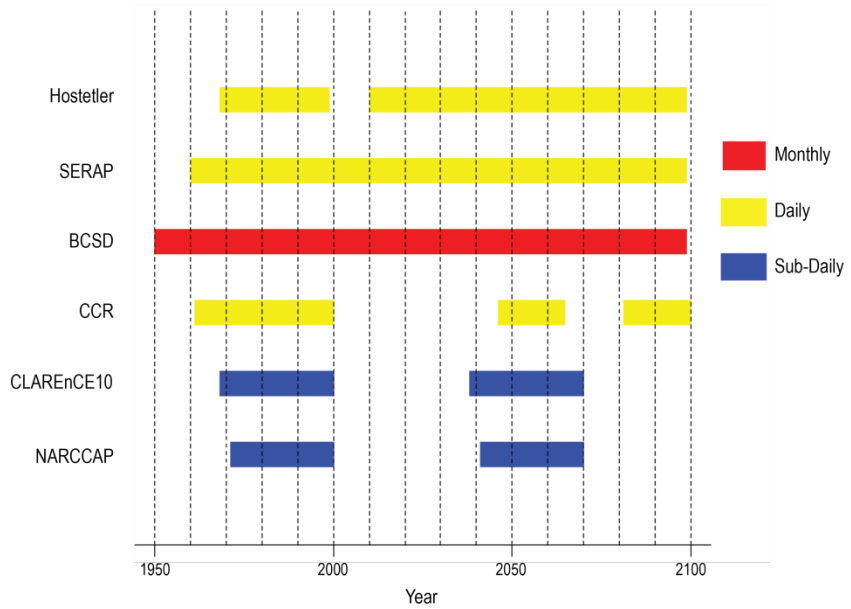

Figure 1. Output time period and temporal resolution for the downscaled datasets.

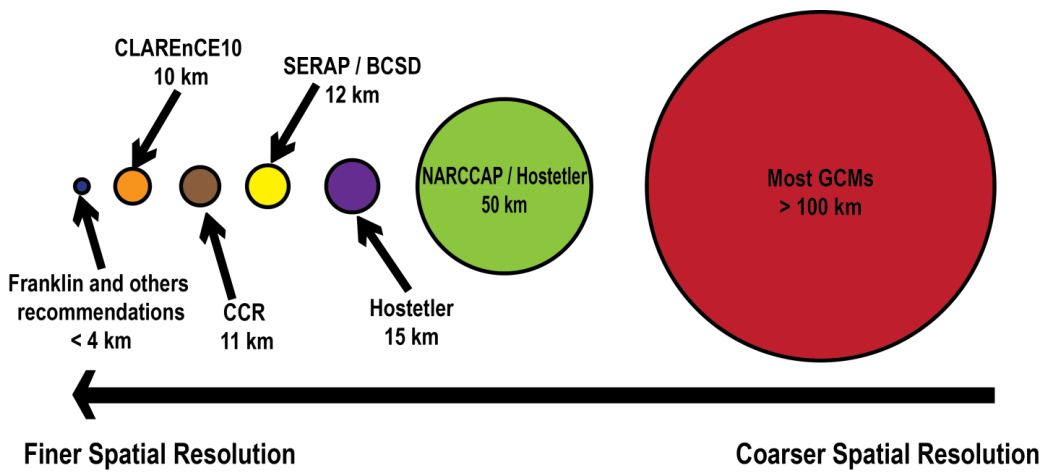

Figure 2. Visualization of spatial resolution differences between Franklin et al (2013) recommendations, the downscaled datasets, and global climate models.

Initial Evaluation

In general, each downscaled dataset has errors during the historical period, which indicates that no single downscaled dataset is best for both temperature and precipitation. However, in some sub-regions a single downscaled dataset can provide the best representation for precipitation or temperature. The results of the evaluation revealed several common threads between downscaled datasets. First, the downscaled datasets created with dynamic techniques tend to have higher errors in temperature and precipitation than those created with statistical techniques. Second, each downscaled dataset has challenges representing temperatures and rainfall in the complex topography of the Southern Appalachians. Figure 3 shows the temperature bias for July for each of the downscaled datasets. Figures 3a, 3b, and 3c are from those

downscaled datasets created with dynamic downscaling. Figures 3d, 3e, 3f are from downscaled datasets created with statistical downscaling. This example shows that the dynamic downscaled datasets have a typically larger error than those created with statistical downscaling. However, each downscaled dataset also has a consistent pattern of error in the Southern Appalachians, though this is more evident in some datasets than others. Finally, each downscaled dataset also underestimates the variability of rainfall during the peak of the Atlantic hurricane season in the Eastern Carolinas. Figure 4 shows the standard deviation difference for September precipitation for each of the downscaled projections. September reflects the peak of the Atlantic Hurricane season. From this figure it is evident that in the Eastern Carolinas and Southeast Virginia the standard deviation of precipitation in September is underestimated by all the downscaled datasets. That is, the interannual variability of precipitation in September is underrepresented by all downscaled projections. This underestimation can be tied to the inability of GCMs to fully represent hurricanes, which gets translated into the downscaled projections and is not corrected by downscaling techniques.

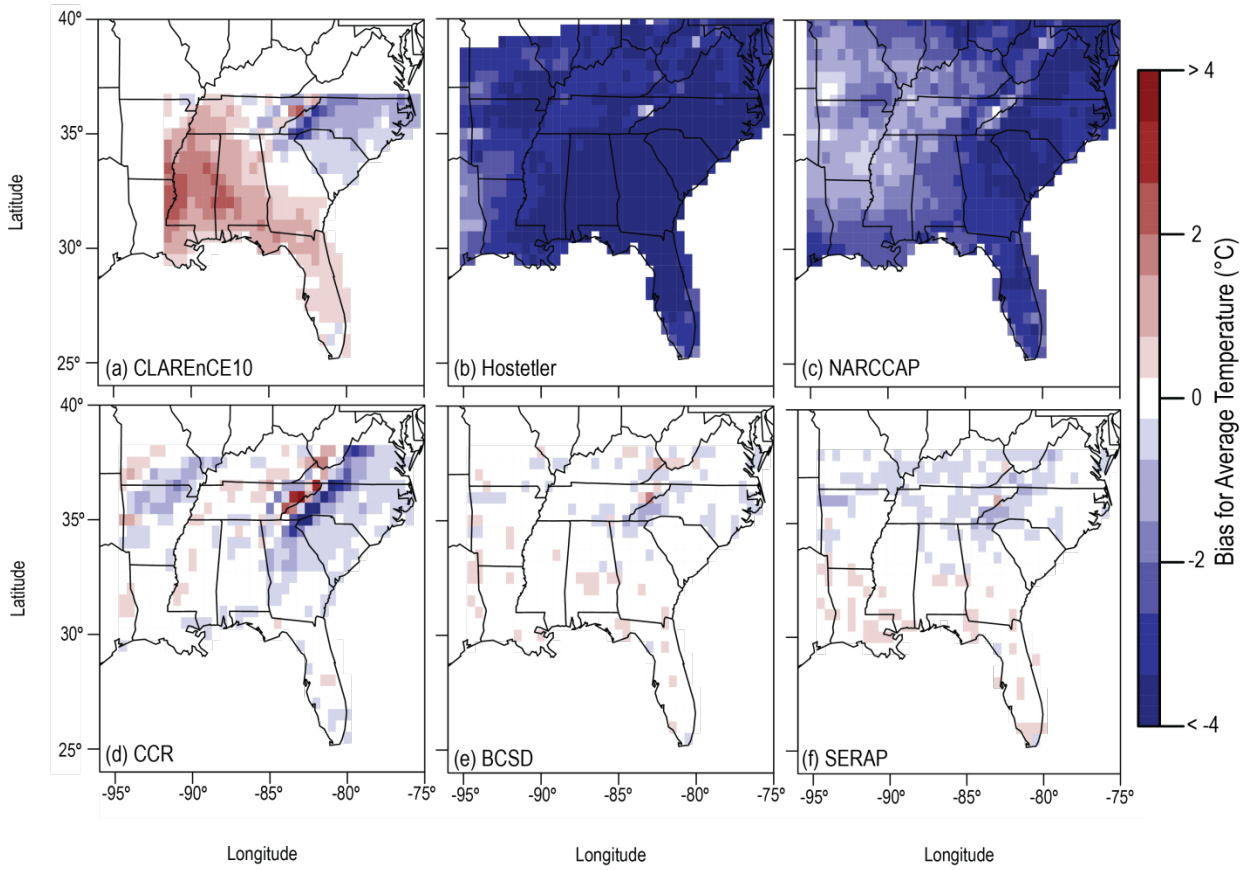

Figure 3. Bias for monthly average temperature (°C) for July for (a) CLAREnCE10, (b) Hostetler, (c) NARCCAP, (d) CCR, (e) BCSD, (f) SERAP.

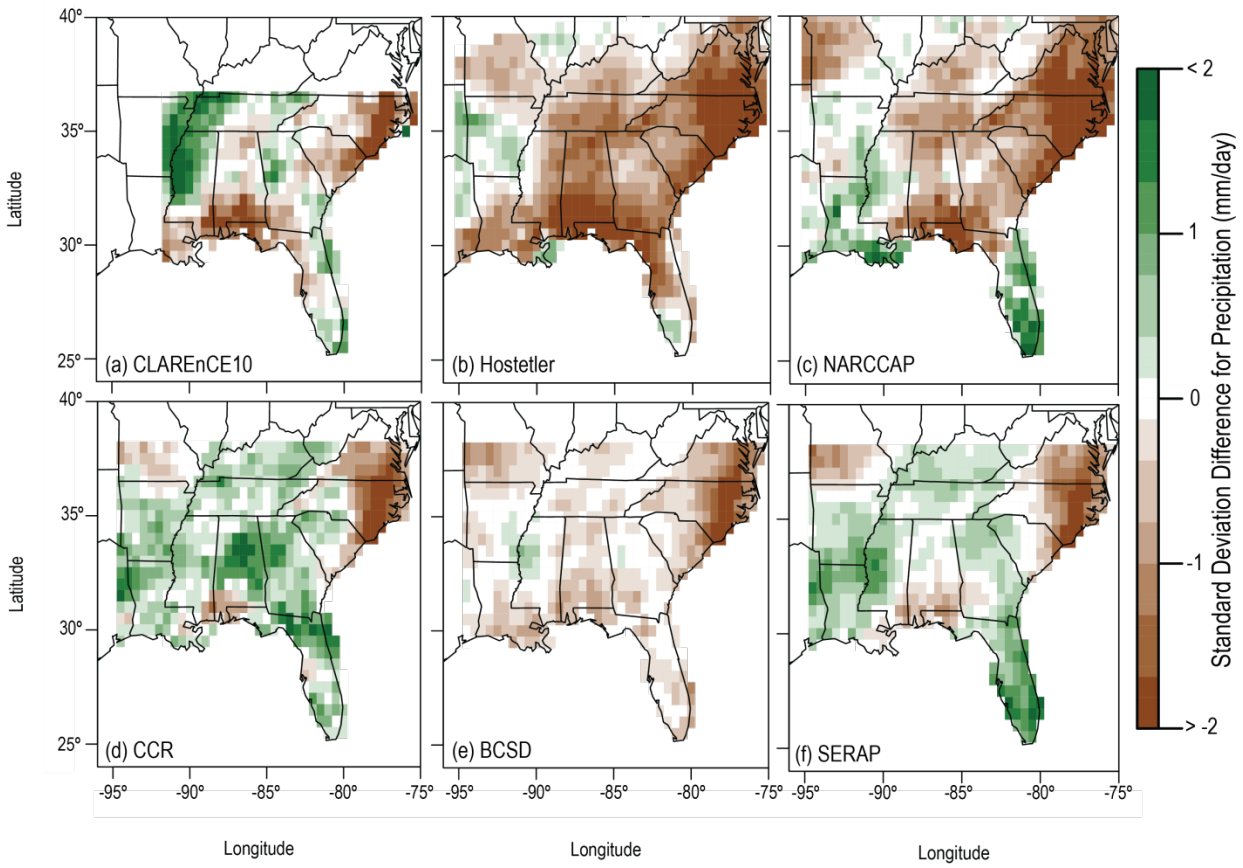

Figure 4. Standard deviation differences across the Southeast for (a) CLAREnCE10, (b) Hostetler, (c) NARCCAP, (d) CCR, (e) BCSD, and (f) SERAP for September precipitation (mm/day).

7. ANALYSIS AND FINDINGS

In keeping with the twofold nature of the project, this section will discuss the major findings related to each section separately. The findings of the project have also been published in a report via USGS. The citation for this report is:

Wootten, Adrienne, Smith, Kara, Boyles, Ryan, Terando, Adam, Stefanova, Lydia, Misra, Vasu, Smith, Tom, Blodgett, David, and Semazzi, Fredrick, 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 p.*http://dx.doi.org/10.3133/ofr20141190*.

Information Synthesis

While the differences in metadata between downscaled datasets are well known by the climate community to be related to the downscaled techniques. However, this has been less acknowledged by ecological modelers and conservation decision makers in the Southeast. As such, a major result of the final report is laying at the fundamental metadata differences that result from different downscaling techniques. Dynamic downscaling approaches are much more computationally expensive, which results in the limited number of GCMs and emissions scenarios used in downscaling. This also limits the time

periods available to historical and future time slices instead of a continuous time period. Since dynamic downscaling is based upon consistent physics of the atmosphere and oceans, these techniques can provide many more variables related to ecological modeling and decision making at finer temporal resolutions. Some of these variables include temperatures aloft, wind speed and direction, and fluxes in heat and moisture between the surface and the atmosphere. Statistical downscaling approaches are much less computationally expensive, and therefore can provide information from more GCMs and emissions scenarios, along with a continuous time period.

Aside from highlighting the need for continuous engagement between the ecology and climate communities in the Southeast, the literature and workshop participants highlighted two other areas of disconnections between the communities. The first of these is the issue of the spatial resolution of the downscaled datasets. Often the ecological modeling done for vulnerability assessments requires that the climate data be at a fine enough resolution to match the scale of the species, habitat, or ecosystem of interest. In mountainous regions, previous studies indicated that a spatial resolution of 4km or finer should be provided by the downscaled datasets for meaningful vulnerability assessments. However, in regions with less complex topography the appropriate spatial resolution for the downscaled datasets for meaningful use in assessments has not been determined. It has been speculated to be 10km or finer (Tom Smith, personal communication), but the literature and workshop participants did not identify studies which approach this question in less complex topography. While the ecological community requires fine spatial resolution climate data, the ability to produce downscaled datasets at that resolution is limited. First, dynamic downscaling techniques require a large amount of computing power, leading to a large amount of time to run simulations and/or requiring a large number of computer processors. This expense is also connected to the spatial resolution desired, increasing with increasingly fine resolution. Second, since statistical downscaling requires observations and observations do not often have a resolution finer than 4km. Finally, while it is possible to downscale to resolutions finer than 4km there are questions in the climate community regarding how meaningful the results will be. The ability to determine how meaningful the results are is also limited by the availability of observations at a resolution finer than 4km. Therefore, addressing the appropriate spatial resolution of downscaled datasets can be identified as a critical future need for more effective vulnerability assessments and decision making. The second area highlighted involved the need for fundamental information on the critical climate sensitivities of species and ecosystems in the Southeast. The National Climate Assessment Southeast Technical Report (Ingram et al, 2013) highlighted this, and the compilation of studies we reviewed also leads to this finding. In the compilation of studies we reviewed, several provided an indication of the specific climate sensitivity of individual species (i.e. number of days the low temperature < 32F). However, many studies were less specific (low temperatures or temperature). As such, there is a need from more information from the ecology community on critical climate sensitivities of different species and habitats.

Initial Evaluation

Since the evaluation was done to a subset of downscaled datasets, we immediately recognize that this subset is not exhaustive, but many common findings can be drawn based upon the results. Many of these findings are also acknowledged by the climate community, but the report from this project lays out these findings clearly for the ecological community in the Southeast. First, the dynamic downscaling techniques do tend to have more biases than statistical downscaling approaches in the raw data available. Each downscaling technique inherits the biases of the GCMs. However, the statistical techniques often incorporate bias correction in the downscaling technique. In contrast, the dynamic downscaling techniques do not incorporate bias correction in the technique itself. Therefore, the raw output from dynamic downscaling techniques will have biases inherited from the GCMs. A downscaled dataset should not be disqualified from use simply for having bias. There are several simple techniques which can be used to remove the bias from dynamic downscaled datasets, and in general this should be done prior to using a dynamic downscaled dataset. Following bias correction, the dynamic downscaled datasets take similar patterns in error compared to those downscaled datasets created with statistical

downscaling. Second, each downscaled dataset evaluated also demonstrated a tendency to underestimate precipitation variability in September, the peak of the Atlantic hurricane season. The challenge associated with hurricanes is representing the precipitation the results from hurricanes with the appropriate frequency. This is a challenge for statistical downscaling techniques, but also for dynamic downscaling techniques because the lack of hurricanes in the driving GCM is translated into the output of dynamic downscaling for precipitation and related variables. Therefore, while bias correction is important to consider, it is also important to carefully consider how accurately any downscaled dataset reproduces the influence of hurricanes on critical variables of interest. Third, complex topography is a challenge for many downscaled climate projections. For the Southern Appalachians as a whole, each set of downscaled climate projections captures the annual cycle of monthly mean temperature and precipitation, but tends to underestimate the inter-annual variability of both temperature and precipitation. However, using downscaled projections in areas of complex topography requires a consideration of the spatial patterns of temperature and precipitation. Each set of downscaled projections in this analysis showed a significant tendency to overestimate temperatures on the west side of the mountains and underestimate temperatures on the east side. This suggests that capturing the appropriate changes in temperature with rapid changes in elevation may also be an issue for each of the downscaled climate projections. As such, the ability to capture changes related to topography in addition to the overall pattern across a region. Finally, though certain downscaled projections performed well in individual regions for individual variables, there is no single downscaled projection which performs best for all variables over the entire Southeast U.S. A similar finding already exists with regards to GCMs, but this is the first time as of this writing that this is empirically demonstrated for downscaled projections in a smaller region. The choice of using a downscaled climate projection should thus be made in the context of the decision or impact assessment requiring downscaled projections. The recommendations here echo those of Chaturverdi et al (2012). For impact assessments and decision making it is recommended to consider using an ensemble of downscaled projections to capture the uncertainty, strengths, and weaknesses represented by the variety of GCMs and downscaling techniques available.

8. CONCLUSIONS AND RECOMMENDATIONS

Based upon the results of the project, there are several conclusions involved in both portions of the project. First, the original intent in the creation of each set of downscaled projections implies that there will be differences in the spatial resolution and domain, temporal resolution, time periods covered, emissions scenarios used, GCMs used, and the variables available for impact assessments and decision making. Much of this is based upon the choice of downscaling techniques used in the creation of each set of downscaled projections. Statistical downscaling techniques can make use of a wide range of emissions scenarios and GCMs, but are often limited to temperature and precipitation as these variables have long observation records. Dynamic downscaling techniques provide many more variables, but are the computational expense of such techniques limits the number of emissions scenarios and GCMs which can be provided. Second, the influence of hurricanes and complex topography should be carefully considered by those doing impact assessments or decision making where these are critical to a species or habitat of interest. The challenge of representing hurricanes in global models and in downscaled projections leads to an underestimate of the inter-annual variability of precipitation during the peak of hurricane season in the eastern Carolinas and Southeast Virginia. Complex topography leads to rapid changes in temperature and rainfall over short distances. This is shown to be a challenge for each set of downscaled projections, and this is therefore important to consider carefully when using projections in the Southern Appalachians. Third, it is important to recognize that for downscaled projections created with dynamic downscaling, the projections are typically provided without bias correction. Those created with statistical approaches are often provided with any biases removed. Downscaled projections should not be disregarded only because of bias. As shown in this analysis, with the bias removed a set of dynamic downscaled projections shares similar patterns of error to those created with statistical downscaling. Therefore, it is important with

projections to focus on the projected change of each variable and not the raw value. However, if the raw value is required, bias correction should be performed with those downscaled projections created with dynamic downscaling. Alternatively, the projected change can be added to a historical climatology created with observations to produce an estimate of the actual value for those applications that require it. Finally, there is no single set of downscaled projections which best represents all aspects of temperature and precipitation across the entire Southeast. Therefore, it is important to consider using more than one set of downscaled projections for an impact assessment or conservation decision. This echoes the recommendations of Chaturverdi et al (2012), which focused on GCMs. However, this can now be extended to downscaling techniques and the associated downscaled projections.

There are also several recommendations regarding the direction of future research efforts. First, it is apparent from the literature review that there is a need to consolidate what is known about the climate sensitivities of critical species and habitats in the Southeast. A large body of such knowledge exists, but gathering and synthesizing such knowledge would be of value to climatologists interested in working with ecologists and natural resource decision makers in the future. Such a synthesis of ecological literature was beyond the scope of this project, but would be valuable for future collaborative research and engagement activities. Second, if there is no specific decision context involved, the evaluation of downscaled projections should consider a broad range of elements. That is, evaluation in absence of a decision context or impact assessment should consider averages and variability of temperature, precipitation, winds, evapotranspiration, and humidity (where possible). In a particular decision context, the climate variables can be refined to those which affect the species, habitat or ecosystem of interest. Third, this project performed an initial evaluation of those variables most critical to Southeast ecosystems. Therefore, this evaluation should be expanded to additional variables in terms of averages, variability, and extremes. Some examples of other variables include evapotranspiration and humidity, along with critical thresholds of temperature and precipitation (i.e. number of days with temperature greater than 32°C). In addition, there should also be a focus on including more GCMs from each set of downscaled projections, and incorporate downscaled projections created with the most recent set of GCMs used in the IPCC Fifth Assessment Report. Finally, the evaluation done in this project should be considered a basic guide to the accuracy of each set of downscaled climate projections. However, the list of projections included was not exhaustive, and the evaluation was not specific to any decision context or impact assessment. Therefore, it is strongly recommended that further engagement between the climatologists, ecologists, and conservation managers in the Southeast be encouraged. This will allow the needs of each community to be more effectively addressed by the others, but also allow for more effective evaluation of downscaled projections in the context of a conservation decision or impact assessment. At local levels this can be promoted by the Landscape Conservation Cooperatives (LCCs) by highlighting relevant studies that are collaborative in nature between communities. The LCCs and the SECSC can also actively work to connect these communities by promoting an online directory of scientists and managers, along with facilitating collaborative efforts between scientific communities that also engage and work with natural resource managers.

9. MANAGEMENT APPLICATIONS AND PRODUCTS

The work in this study was a first step in engagement of the multidisciplinary scientific and decision making communities which are involved in the SECSC. It provides insight into the subtleties of creating downscaled projections and the associated implications for the ecology community and natural resource managers. The final report provides several recommendations for users of downscaled projections regarding important aspects to consider related to a decision. It is expected that this project and associated reports will provide a basis for ecologists involved in impact assessments and managers involved in climate change conservation decisions to engage with climatologists familiar with downscaled projections. It is expected this will aid end users regarding how to use downscaled projections

appropriately, which will lead to more effective and efficient decision making and impact assessments. In addition, the contents of the report communicated to climatologists will provide insight on how downscaled projections are used by end user groups, influencing the development of future projections related to natural resources.

A group of scientists actively involved in research and conservation decision making provided guidance to the investigators throughout the project. These include the following:

- Rua Mordecai, South Atlantic Landscape Conservation Cooperative
- Jayantha Obeysekera, South Florida Water Management Division
- Laurie Rounds, NOAA Office of Ocean and Coastal Resource Management – Coastal Programs Division
- Laura Thompson, National Climate Change and Wildlife Science Center
- John Tirpak, Gulf Coastal Plains Ozarks Landscape Conservation Cooperative
- Steve Traxler, Peninsular Florida Landscape Conservation Cooperative

It also brought together approximately 50 scientists and decision makers in a 2013 workshop to discuss the use of downscaled projections in decision making. A full description of the workshop is available in a published paper highlighted in the next section. This workshop was facilitated in collaboration with Jared Bowden (UNC Institute for the Environment) and Tanya Spero (U.S. Environmental Protection Agency).

10. OUTREACH

We completed a report which has been published via USGS. The citation for this report is:

Wootten, Adrienne, Smith, Kara, Boyles, Ryan, Terando, Adam, Stefanova, Lydia, Misra, Vasu, Smith, Tom, Blodgett, David, and Semazzi, Fredrick, 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 p.*http://dx.doi.org/10.3133/ofr20141190*.

In addition to the above, a workshop review article was also published in early 2014. The citation for this article is:

Adrienne Wootten, Kara Smith, Jared Bowden, Tanya Otte, and Ryan Boyles 2014. Regional Climate Variations and Change for Terrestrial Ecosystems Workshop Review. Bulletin of the Ecological Society of America 95:96–97. http://dx.doi.org/10.1890/0012-9623-95.1.96

Finally, two other products will be created as a result of this project. First, a factsheet (and associated video) highlighting the main findings and recommendations of the report is being created and will ultimately be published by the SECSC. Second, a decision support tool to aid in the selection of downscaled projections for impact assessments and decision making is being created by the State Climate Office of North Carolina. This tool will ultimately be hosted by the SECSC.

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