TACCIMO
Template for Assessing Climate Change Impacts and Management Options

TACCIMO CLIMATE REPORT

Report Date: 4-1-2013
Location: Francis Marion National Forest

HOW TO CITE INFORMATION IN THIS REPORT

The following sources should be directly cited when discussing or summarizing results in this report.

PRISM Historic Climate:
Gibson, W.P., C. Daly, T. Kittel, D. Nychka, C. Johns, N. Rosenbloom, A. McNab, and G. Taylor. 2002. Development of a 103-year high-resolution climate data set for the conterminous United States. In: Proceedings, 13th AMS Conference on Applied Climatology, American Meteorological Society, Portland, OR, May 13-16, 181-183.

GCM Climate Projections (Girvetz et al. produced the ensembles using Meehl et al. downscaled data):
Girvetz, E.H., C. Zganjar, G.T. Raber, E.P. Maurer, P. Kareiva, and J.J. Lawler. 2009. Applied climate-change analysis: the Climate Wizard tool. PLoS ONE 4(12): e8320. doi:10.1371/journal.pone.0008320.

Meehl, G.A., C. Covey, T. Delworth, M. Latif, B. McAvaney, J.F.B. Mitchell, R.J. Stouffer, and K.E. Taylor. 2007. The WCRP CMIP3 multi-model dataset: a new era in climate change research. Bulletin of the American Meteorological Society 88: 1383-1394.

This report was generated by ACCIMO and may be acknowledged by using the name and date listed above, along with the TACCIMO website (www.taccimo.sgcp.ncsu.edu).

BEST AVAILABLE SCIENTIFIC INFORMATION

The scientific information summarized within this report is drawn from a comprehensive and accessible inventory of downscaled climate data available for the conterminous US. The ensembles derived by Girvetz et al. (2009) provide efficient insight into the broad range of model variability, which is a particularly valuable in the context of gauging uncertainty, especially in the near term. When available, the results included in this report can be considered as broad context for regionally downscaled future projections that may be more appropriate for a given area or question.

NEXT STEPS

Review the results contained in the climate report and use the "climate report worksheet" provided by TACCIMO to assist in a structured analysis, including the interpretive guidance on assessing uncertainty of model projections. Present the information summarized in this report to specialists on your team and request feedback as it relates to specific resources or conditions of interest or concern. Consult with local experts and stakeholders to further evaluate the merit and implications of this information. For methods and criteria on the inclusion of geospatial content in TACCIMO, see the TACCIMO user guide, section Science: Geospatial–Projections and Models.

REPORT STORAGE/ARCHIVAL

This report may be appropriate as an appendix to a specialized analysis or may be included in an administrative record.

REPORT CONTENTS

This climate report provides a summary of climate projections for a specified area and time period. The climate variables available include temperature and precipitation, and those variables can be presented as absolute values or changes from historic (1961-1990) and summarized in either metric or English units.

Climate Variable		Units		Values	
Temperature	X	Metric (°C, cm)		Absolute	X
Precipitation	X	English (°F, in)	X	Change (%)	

Future climate projections are derived from Climate Wizard parametric ensembles (Girvetz et al. 2009). For each time period and location, the minimum, 25th percentile, median (50th percentile), 75th percentile, and maximum projections are included for the temperature and precipitation variables. IPCC SRES emission scenarios range from low (B1) to high (A2). Raupach et al. (2007) states that emissions between 2000 and 2004 were closest to the A2 scenario trajectory.

Climate Model Type		Ensemble Percentile Range		SRES Emission Scenarios	
Ensemble	X	Maximum (100%)	X	B1 (low)	X
Individual GCMs		75%	X	A1B (middle)	
		Middle (50%)	X	A2 (high)	X
		25%	X		
		Minimum (0%)	X		

Climate summaries are available in table, chart, and map form and can be generated for annual, seasonal, or monthly time steps. There are two historic time periods available, both spanning 1961-1990. The observed historic data are derived from PRISM (Gibson et al. 2002), and the predicted historic data are derived from the Climate Wizard ensemble projections (Girvetz et al. 2009). The other time periods span 30 years each and are all derived from Climate Wizard ensemble projections.

Time Step	Table	Chart	Map	Time Periods	Table	Chart	Map
Annual	X	X	X	1980-2009 (PRISM Observed ~4km)	X	X	X
Seasonal	X	X		1980-2009 (GCM Predicted ~12km)	X	X	X
Monthly				2010-2039 (GCM Predicted ~12km)	X	X	
				2040-2069 (GCM Predicted ~12km)	X	X	
				2070-2099 (GCM Predicted ~12km)	X	X	

Climate summaries are available across several geographic scales, ranging from the coarsest, national scale, down to state, county, or national forest. Summaries will differ at different scales.

Geographic Scale		
National		
State		
County		
National Forest	X	Francis Marion NF

This climate report provides a summary of climate projections for the Francis Marion National Forest (figure 1). Climate projections at scales consistent with those used by land managers and planners are critical for understanding the effects of climate change on natural resources. This summary provides climate projections relevant for scenario planning exercises and vulnerability assessments. The report is also intended for resource managers and others to understand anticipated climate change, and may be used in other reports and publications. In addition, the climate projections in this report provide context for considering potential effects, management options, and their planning implications.

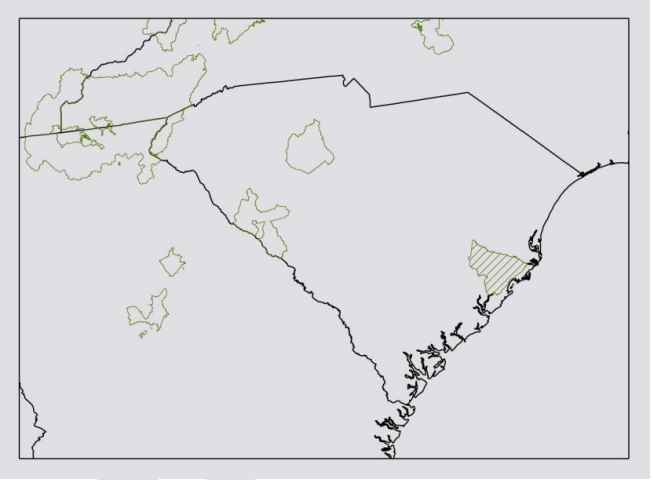

Figure 1—Overview of the Francis Marion National Forest (polygon with diagonal lines) and South Carolina state boundary

HISTORIC CLIMATE

Different representations of historic climate are summarized in tables 1 and 2 for temperature and precipitation respectively. The spatial patterns of annual temperature and precipitation are included in figure 2. The intent of providing multiple representations of historic climate is to establish a chain of logic enabling analysis of future projections at coarse scales (~12km) with respect to historic reference conditions that are observationally based and available at finer scales (~4km). The Girvetz et al. (2009) representation of historic climate will serve as the baseline for comparison with future climate projections in subsequent sections of this report.

Table 1—Summary of annual and seasonal historic temperature from 1980-2009

	Annual	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
	---------- Degrees F ----------				
Observed Historic (PRISM; Gibson et al. 2002)	64.7	49.0	63.7	79.9	66.1
Predicted Historic (GCM[1]; Girvetz et al. 2009)	65.0	49.1	64.5	80.1	66.1

[1] Average of the median A2 ensemble value. Values from other ensembles and from the B1 scenario are included in the future climate section.

Table 2—Summary of annual and seasonal historic precipitation from 1980-2009

	Annual	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov
	---------- Inches of Precipitation ----------				
Observed Historic (PRISM; Gibson et al. 2002)	50.6	10.5	10.4	17.5	12.3
Predicted Historic (GCM[1]; Girvetz et al. 2009)	51.1	10.6	10.7	18.1	11.2

[1] Average of the median A2 ensemble value Values from other ensembles and from the B1 scenario are included in the future climate section.

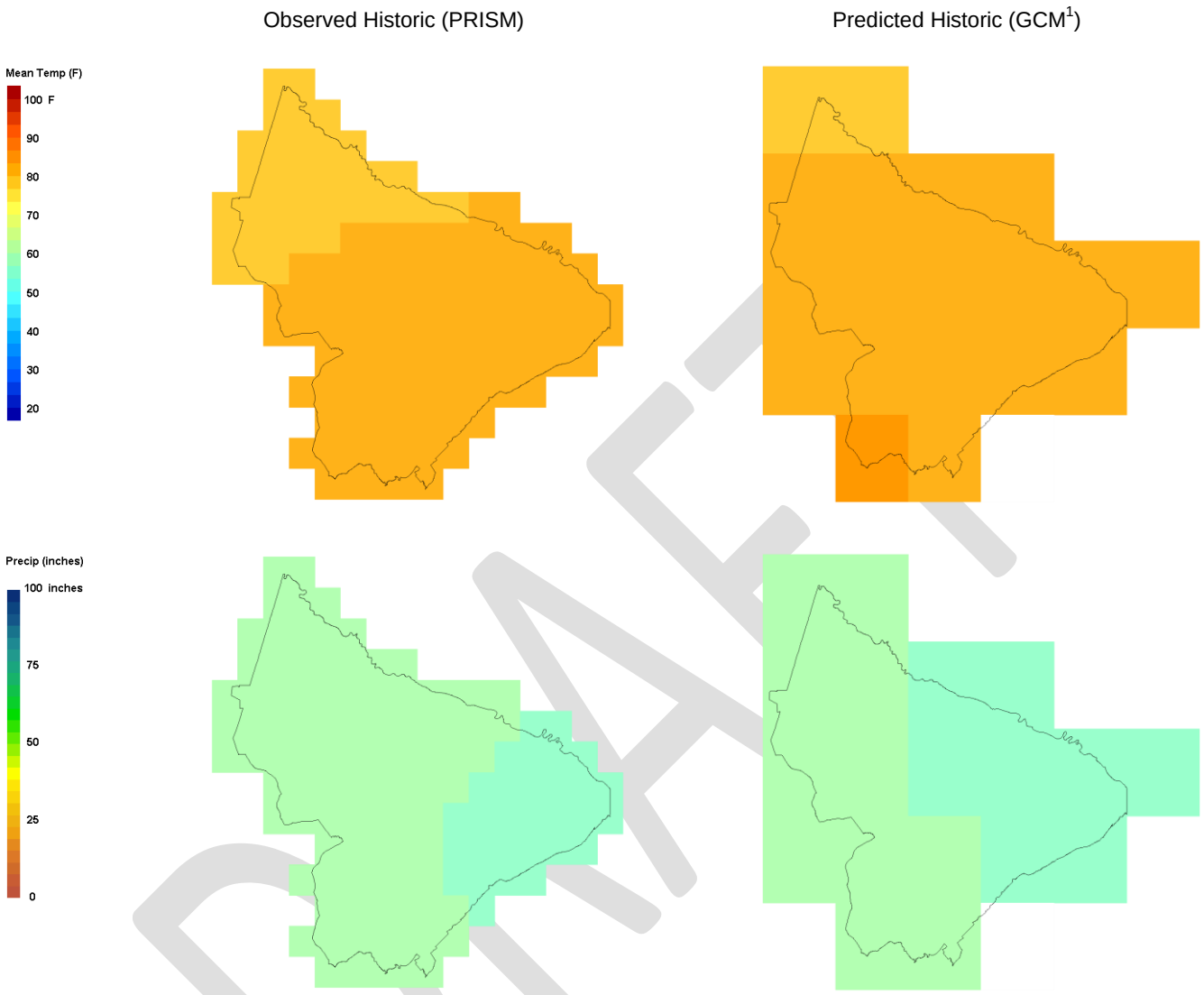

Figure 2—Map displaying spatial patterns of average annual temperature and precipitation from 1980-2009 based on observed historic (PRISM; Gibson et al. 2002; 4km) and modeled historic (GCM; Girvetz et al. 2009; Meehl et al. 2007;12km)
[1]Median A2 ensemble value

FUTURE CLIMATE

This section summarizes basic measures of future projected climate from Climate Wizard ensembles. For each time period and location, the 25th percentile, median (50th percentile), and 75th percentile projections are included for precipitation and temperature. Maximum and minimum values are also provided to give insight to the full range of model uncertainty.

Annual Projections

Table 3—Summary of temperature from ensemble projections and historic over the selected time periods (Girvetz et al. 2009; Meehl et al. 2007)

Time Period	Scenario	Minimum	25th	50th	75th	Maximum
		----------Degrees F----------				
1980-2009	B1	64.7	64.9	65.1	65.2	65.7
	A2	64.6	64.9	65.0	65.3	65.5
2010-2039	B1	65.9	66.1	66.2	66.4	66.9
	A2	65.5	66.0	66.3	66.5	66.8
2040-2069	B1	66.2	66.9	67.3	67.5	67.9
	A2	66.9	67.9	68.1	68.3	69.1
2070-2099	B1	66.5	67.5	68.0	68.5	69.4
	A2	67.9	69.9	70.5	71.1	72.6

Table 4—Summary of precipitation from ensemble projections and historic over the selected time periods (Girvetz et al. 2009; Meehl et al. 2007)

Time Period	Scenario	Minimum	25th	50th	75th	Maximum
		----------Inches----------				
1980-2009	B1	47.8	49.6	51.1	51.8	53.5
	A2	48.5	49.3	51.1	52.1	53.7
2010-2039	B1	47.7	50.5	52.6	54.5	57.7
	A2	44.6	49.6	52.5	55.6	59.7
2040-2069	B1	39.4	51.3	53.0	54.8	59.5
	A2	46.4	50.7	52.3	56.9	62.3
2070-2099	B1	34.7	48.8	55.3	56.4	58.8
	A2	47.8	49.6	51.1	51.8	53.5

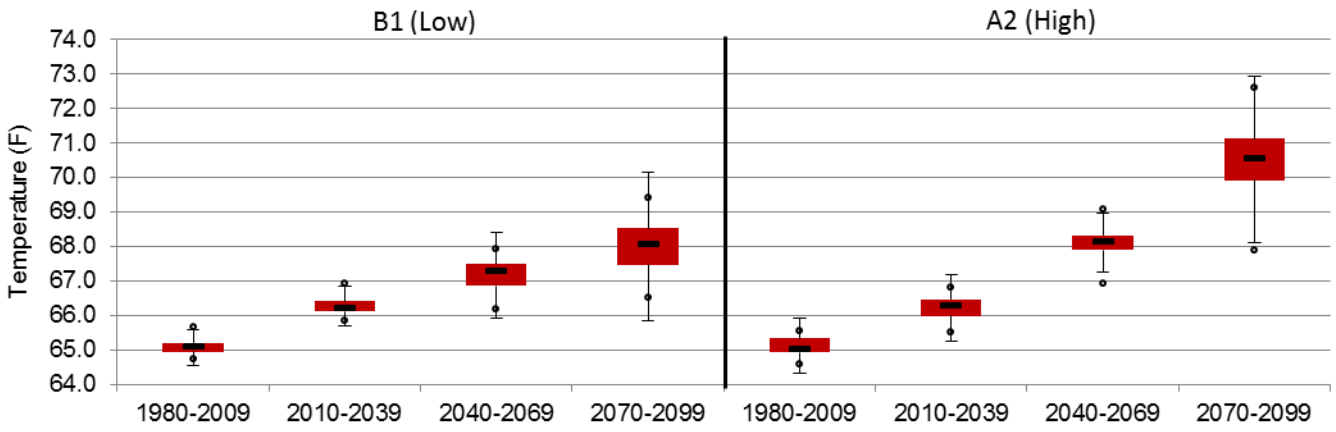

Figure 3—Box and whisker plots of projected mean annual temperature depicting the 25th – 75th percentile (interquartile range; IQR, or 75th percentile minus the 25th percentile) as the red box with the median value marked with a dash. The error bars represent uncertainty as calculated from 1.5*IQR, with potential outliers (maximum and minimum ensembles) represented by small circles (Girvetz et al. 2009; Meehl et al. 2007).

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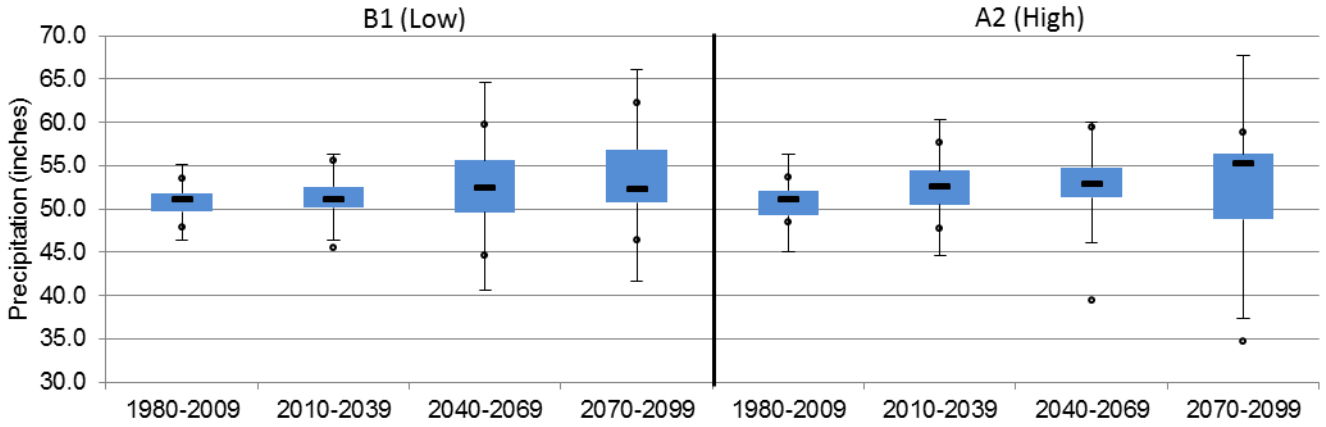

Figure 4—Box and whisker plots of projected mean annual precipitation depicting the 25th – 75th percentile (interquartile range; IQR, or 75th percentile minus the 25th percentile) as the blue box with the median value marked with a dash. The error bars represent uncertainty as calculated from 1.5*IQR, with potential outliers (maximum and minimum ensembles) represented by small circles (Girvetz et al. 2009; Meehl et al. 2007).

Seasonal Projections

Table 5—Summary of seasonal temperature from ensemble projections over the selected time periods (Girvetz et al. 2009; Meehl et al. 2007)

Season	Time Period	Scenario	Minimum	25th	50th	75th	Maximum
			Degrees F				
Dec-Feb	1980-2009	B1	47.2	48.9	49.4	49.8	51.1
		A2	48.2	48.8	49.1	49.8	50.3
	2010-2039	B1	49.2	49.9	50.5	50.9	51.6
		A2	49.0	49.8	50.1	50.7	51.8
	2040-2069	B1	49.5	50.3	51.0	51.7	52.6
		A2	50.4	51.1	51.6	52.5	53.3
	2070-2099	B1	49.5	51.0	51.7	52.7	53.2
		A2	51.0	52.9	53.5	54.3	56.0
Mar-May	1980-2009	B1	63.4	64.2	64.5	64.8	65.4
		A2	63.8	64.2	64.5	64.9	65.1
	2010-2039	B1	64.7	65.4	65.6	66.0	66.7
		A2	64.2	65.2	65.6	65.9	66.6
	2040-2069	B1	64.9	66.1	66.8	67.0	67.9
		A2	65.6	66.8	67.4	68.0	68.7
	2070-2099	B1	66.0	66.6	67.7	68.1	68.5
		A2	67.4	69.1	69.8	70.5	71.8
Jun-Aug	1980-2009	B1	79.3	79.8	79.9	80.3	80.7
		A2	79.5	79.9	80.1	80.4	80.6
	2010-2039	B1	80.6	81.0	81.3	81.6	82.4
		A2	80.5	81.0	81.3	81.7	82.4
	2040-2069	B1	81.1	81.8	82.3	82.6	83.5
		A2	81.7	83.0	83.3	83.8	84.9
	2070-2099	B1	81.5	82.6	83.1	83.7	84.4
		A2	83.1	85.4	85.9	86.9	88.5
Sep-Nov	1980-2009	B1	64.5	65.8	66.2	66.5	67.7
		A2	65.3	65.8	66.1	66.6	67.0
	2010-2039	B1	66.3	67.0	67.3	67.7	68.7
		A2	66.3	67.1	67.7	67.9	68.4
	2040-2069	B1	67.1	67.8	68.5	68.9	69.9
		A2	67.9	68.7	69.5	70.0	71.0
	2070-2099	B1	67.7	68.3	69.2	69.8	70.9
		A2	69.5	71.1	71.9	73.0	74.7

Table 6—Summary of seasonal temperature from ensemble projections over the selected time periods (Girvetz et al. 2009; Meehl et al. 2007)

Season	Time Period	Scenario	Minimum	25th	50th	75th	Maximum
			inches				
Dec-Feb	1980-2009	B1	9.1	10.2	10.4	10.9	12.4
		A2	9.4	10.1	10.6	11.1	12.3
	2010-2039	B1	8.7	10.0	10.6	11.1	13.2
		A2	8.3	10.1	10.8	11.6	13.2
	2040-2069	B1	8.5	9.8	10.7	11.6	13.6
		A2	8.5	9.5	10.7	12.1	14.3
	2070-2099	B1	7.7	9.6	10.7	12.0	13.7
		A2	7.1	9.9	11.2	12.3	15.0
Mar-May	1980-2009	B1	9.8	10.3	10.9	11.4	12.2
		A2	9.8	10.2	10.7	11.2	11.9
	2010-2039	B1	8.8	10.0	10.6	11.2	13.1
		A2	9.0	10.4	11.1	11.8	14.3
	2040-2069	B1	8.7	9.6	10.5	11.6	13.4
		A2	8.0	9.7	10.5	11.1	13.0
	2070-2099	B1	9.3	10.0	10.9	11.7	13.4
		A2	6.7	9.1	10.1	11.1	13.7
Jun-Aug	1980-2009	B1	15.9	17.2	17.8	18.6	20.2
		A2	16.0	17.3	18.1	18.8	20.2
	2010-2039	B1	14.3	17.0	18.0	18.9	22.1
		A2	15.1	16.5	18.1	20.3	22.4
	2040-2069	B1	13.5	17.1	18.2	20.5	22.9
		A2	12.4	16.1	18.3	20.6	23.7
	2070-2099	B1	12.9	16.3	18.4	20.6	25.0
		A2	10.5	16.6	18.8	21.2	24.9
Sep-Nov	1980-2009	B1	9.2	10.7	11.2	12.0	13.5
		A2	9.5	10.5	11.2	12.2	13.6
	2010-2039	B1	8.7	11.0	12.0	12.7	15.3
		A2	9.3	11.0	11.8	13.3	15.4
	2040-2069	B1	9.6	11.4	12.2	13.8	16.5
		A2	9.5	11.6	12.5	13.6	16.6
	2070-2099	B1	9.3	11.6	12.7	13.6	15.5
		A2	7.3	11.8	13.1	14.3	17.6

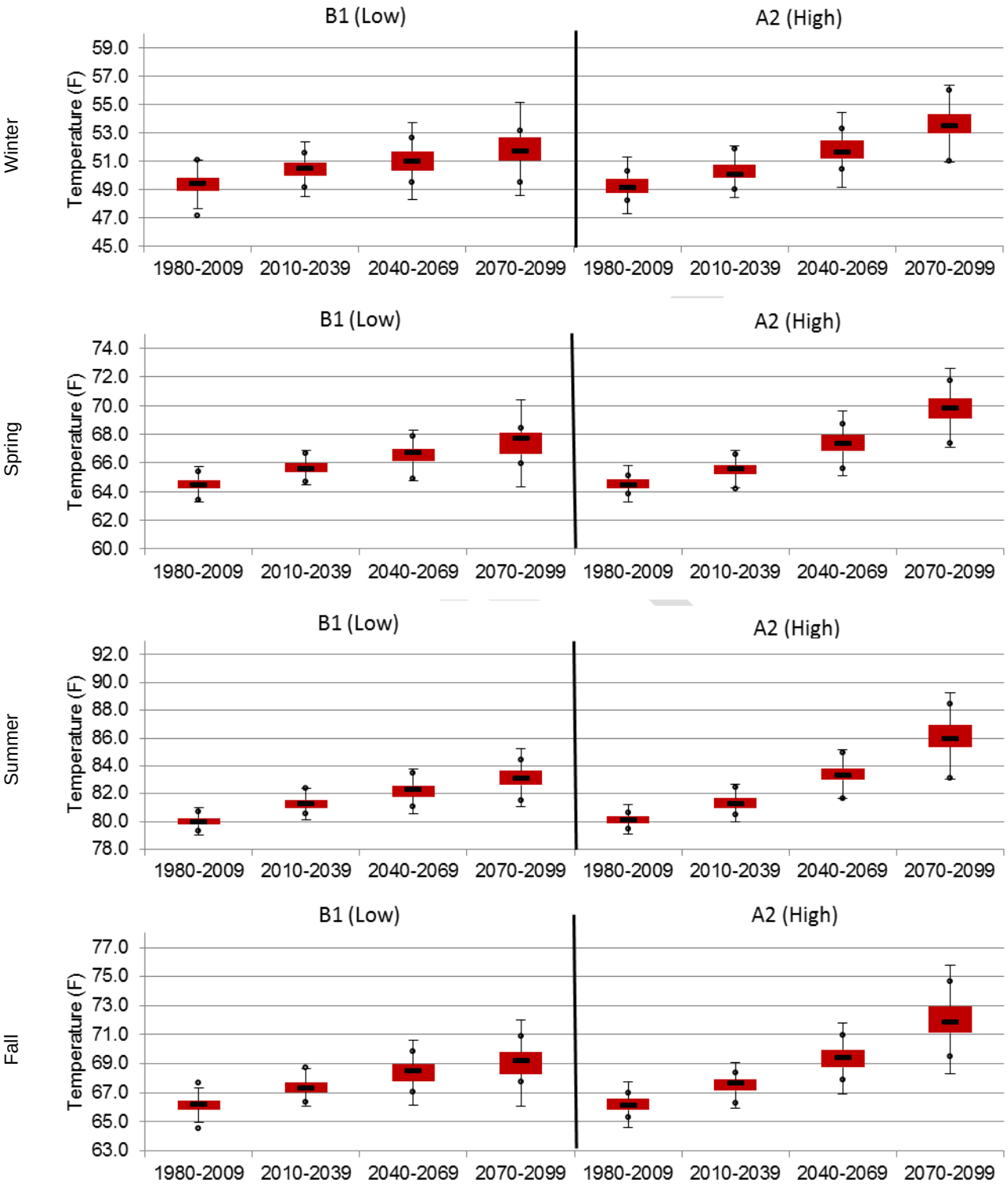

Figure 5—Box and whisker plots of projected mean seasonal temperature depicting the 25th – 75th percentile (interquartile range; IQR, or 75th percentile minus the 25th percentile) as the red box with the median value marked with a dash. The error bars represent uncertainty as calculated from 1.5*IQR, with potential outliers (maximum and minimum ensembles) represented by small circles (Girvetz et al. 2009; Meehl et al. 2007)

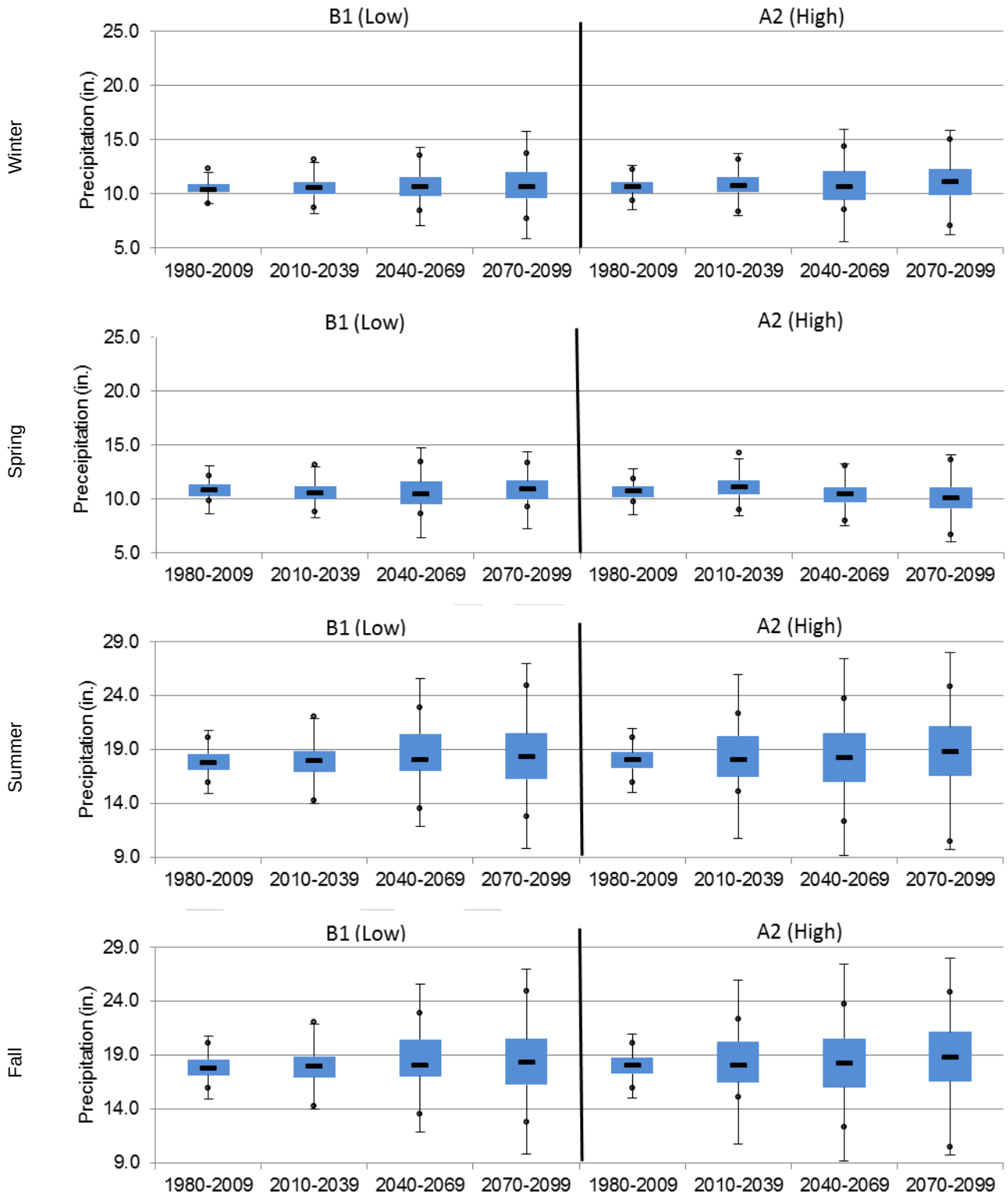

Figure 6—Box and whisker plots of projected mean seasonal precipitation depicting the 25th – 75th percentile (interquartile range; IQR, or 75th percentile minus the 25th percentile) as the blue box with the median value marked with a dash. The error bars represent uncertainty as calculated from 1.5*IQR, with potential outliers (maximum and minimum ensembles) represented by small circles (Girvetz et al. 2009; Meehl et al. 2007).

INTERPRETIVE GUIDANCE

Models and Scenarios

The climate projection ensembles included in this report were produced from fifteen downscaled global climate models (GCMs) by The Nature Conservancy's Climate Wizard (Girvetz et al. 2009). Examining ensembles of climate projections helps to quantify the range of possible future climates, instead of considering a single or comparing across individual GCMs. The downscaled GCMs were produced by the Coupled Model Intercomparison Project Phase 3 (CMIP3; Meehl et al. 2007), a critical source of data to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (AR4, IPCC; IPCC 2007).

Each GCM is replicated across common emissions scenarios from the IPCC Special Report on Emissions Scenarios (SRES), which include A2, A1B, and B1, in the order of greatest to least emissions by the end of the 21st century (Nakicenovic et al. 2000). Each of these scenarios project very different future socioeconomic changes, which impact greenhouse gas emissions and, in turn, different rates and levels of climate response, including temperature increase.

Table 7—Summary of IPCC scenarios, emission paths, and descriptions

Scenario	Emissions Path	Description
SRES A2	"higher"	technological change and economic growth more fragmented; slower, higher population growth
SRES A1B	"middle"	technological change in the energy system is balanced across all fossil and non-fossil energy sources, where balanced is defined as not relying too heavily on one particular energy source
SRES B1	"lower"	rapid change in economic structures toward service and information, with emphasis on clean, sustainable technology; reduced material intensity and improved social equity

This report includes parametric ensemble results from 15 GCMs under the B1 and A2 scenario. The median, 25th, and 75th percentiles provide a simplified range of potential future climate. For details on the ensembling process and percentiles, please consult the Climate Wizard website (http://www.climatewizard.org/FAQ.html). Strategies for selecting appropriate GCMs and SRES are available in the *TACCIMO User Guide*, along with additional interpretive guidance.

Assessing Uncertainty and Model Performance

Climate projections at finer geographic and/or temporal scales have greater uncertainty in temperature and precipitation estimates. For this reason, it is prudent the uncertainty in the GCM model results. The following questions can be answered from the results of the TACCIMO Climate Report to provide a standardized approach to assess uncertainty and establish a basis for confidence in the discussion of the future climate.

Historic Climate—Evaluating GCM results with fine scale historic data helps establish a rationale when making comparisons, especially when absolute rather than relative values are important (e.g., considering a threshold for a temperature or moisture sensitive species or system). In general, a future GCM projection should only be directly compared to its own representation of historic climate.

However, other historic climate data (in this case the modeled PRISM results) based on observed climate at finer temporal and geographic scales may provide a more familiar representation of historic climate. As such, it is important to consider the GCM and PRISM (as well as other sources of climate data) to fully assess the potential implications of the projected change. It is also important to note that differences between the GCM and PRISM estimates of historic conditions do not by themselves indicate the skill (i.e., quality) of the GCM. Consider the following questions when comparing future with historic climate.

- How do observationally based historic climate estimates from PRISM compare with the historic median ensemble GCM for each variable and temporal resolution?
  - What is the difference between the GCM and PRISM (baseline) historic estimates?
  - If the differences are large (relative to the model uncertainty established for future projections), it may be worth exploring potential reasons (e.g., fine scale topographical influences lost in the coarser scale GCM projections)?

Future Projections—Examine future climate projections for the location of interest and consider the following questions to evaluate model results.

- How do the ensembles compare to one another for each variable and time period (including the historic baseline)?
  - What is the direction of change and range of the ensembles?
  - Does the range of the ensembles change over time?
  - How well does the direction and magnitude of change compare with other projections at different geographic (finer/ coarser) or temporal (finer/ coarser; future/ historic) scales?

METADATA AND DISCLAIMER

Historic climate data were derived from data provided by PRISM Modeling Group at Oregon State University. Parameter-elevation Regressions on Independent Slopes Model (PRISM) data have spatial resolution of 4 km, spatial extent of the conterminous US, temporal resolution of month, and temporal extent of 1895-1997. Data are described in detail in W.P. Gibson, C. Daly, T. Kittel, D. Nychka, C. Johns, N. Rosenbloom, A. McNab, and G. Taylor. 2002. Development of a 103-year high-resolution climate data set for the conterminous United States. In: Proceedings, 13th AMS Conference on Applied Climatology, American Meteorological Society, Portland, OR, May 13-16, 181-183. Data are available at http://www.prism.oregonstate.edu/products/.

Ensembles of climate projections were produced by The Nature Conservancy Climate Wizard. Ensembling methods are described in detail in E.H. Girvetz, C. Zganjar, G.T. Raber, E.P. Maurer, P. Kareiva, and J.J. Lawler. 2009. Applied climate-change analysis: the Climate Wizard tool. PLoS ONE 4(12): e8320. doi:10.1371/journal.pone.0008320. Additional resources and data are available at http://www.climatewizard.org/.

Climate projections were derived from data provided by the World Climate Research Programme's Coupled Model Intercomparison Project Phase 3 (CMIP3) dataset. These downscaled data have spatial resolution of 12 km, spatial extent of the conterminous US, temporal resolution of month, and temporal extent of 2001-2099. Data are described in detail in E.P. Maurer, L. Brekke, T. Pruitt, and P.B. Duffy. 2007. Fine-resolution climate projections enhance regional climate change impact studies. Eos Trans. AGU 88(47): 504. Data are available at http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html. For additional metadata, please see the Metadata - Overview and Metadata - Details links on the TACCIMO GIS Viewer.

This geospatial information was prepared by the USDA Forest Service. These data were developed from sources of differing accuracy, based on modeling or interpretation, accurate only at certain scales, or incomplete while being created or revised. The Forest Service cannot assure the accuracy, completeness, reliability, or suitability of this information for any particular purpose. Using geospatial data for purposes other than those for which they were created may yield inaccurate or misleading results. The Forest Service is not liable for any activity involving this information with respect to losses or damages. In the future, TACCIMO may add more GCMs, derivative models, and context layers. Please continue to check the GIS Viewer for additional datasets (http://www.taccimogis.sgcp.ncsu.edu/TACCIMO/GIS/taccimo_gis.html).

Please include the following acknowledgement when you produce documents based on TACCIMO datasets: "We acknowledge TACCIMO for making the downscaled climate projections, derivative models, and context layers publicly available. Support for these products was provided by the USDA Forest Service Threat Centers, Region 8, and Region 5."

References

Gibson, W.P., C. Daly, T. Kittel, D. Nychka, C. Johns, N. Rosenbloom, A. McNab, and G. Taylor. 2002. Development of a 103-year high-resolution climate data set for the conterminous United States. In: Proceedings, 13th AMS Conference on Applied Climatology, American Meteorological Society, Portland, OR, May 13-16, 181-183.

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