DOCKETED	
Docket Number:	25-BSTD-03
Project Title:	2028 Energy Code Pre-Rulemaking.
TN #:	265692
Document Title:	Weather Data File Updates for the 2028 Energy Code
Description:	This document describes the proposed weather data file updates for the 2028 Energy Code.
Filer:	Javier Perez
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	8/19/2025 1:33:27 PM
Docketed Date:	8/19/2025

Weather Data File Updates for the 2028 Energy Code

December 20, 2024

Prime Contractor

Bruce A. Wilcox, P.E., Inc.
1110 Monterey Ave
Berkeley, CA 94707
510-459-6363
bwilcox@lmi.net

Project Team

Klimaat Consulting — Michael Roth

Big Ladder Software — Neal Kruis, Nathan Oliver

Charles S. Barnaby — Chip Barnaby

Frontier Energy — Alea German, Ada Shen

Proctor Engineering — Abram Conant

Model Efficiency — Dimitri Contoyannis

Table of Contents

List of Figures

List of Tables

DISCLAIMER

Executive Summary

As part of updates to the Energy Code Accounting methodology for the 2028 Energy Code, the California weather data files reflecting future weather conditions were developed for consideration. These files are referred to in this report as “future weather files.” The future weather data conditions used observational weather station data as in past updates to the weather files to reflect forecasted future conditions based on the high-resolution climate model referred to as the Localized Constructed Analogs model (LOCA2). Weather files were developed for each of the 16 California climate zones. The weather files each represent the anticipated typical meteorological year (TMY) for the time period between the years of 2030 and 2059.

The future weather files result in changes in simulated cooling and heating energy for single-family residential and commercial building prototype models—increases in cooling energy and decreases in heating energy are observed. These changes are primarily due to the forecasted warmer temperatures in the future.

The forthcoming 2028 update to weather files, prototypes, plug loads and the Long-term System Cost (LSC) and Source Energy metrics will only apply to nonresidential building types.

Introduction

Weather data files are used for several purposes during the Title 24 energy code update process including, but not limited to, analyzing weather-dependent energy efficiency measures (such as those that may impact heating and cooling energy consumption) by quantifying their impact through the use of whole-building energy simulations, and as an underlying dataset used to generate the Long-Term System Cost (LSC) and hourly Source Energy metrics. The weather data files are also used as an input to compliance software tools that evaluate if a proposed building design complies with the performance path of the Energy Code.

The California weather data files are updated on a regular basis to reflect typical weather conditions in each of the California Climate Zones. Traditionally, the weather files have been based on a collection of recent, historical (past) weather conditions, referred to in this report as “historic weather files” – typically looking back over a period of at least the 20 most recent years in order to best represent recent weather conditions across the state. These files are called typical meteorological year (TMY) files. The weather data files were previously updated using this approach in 2023 to support the 2025 energy code development process.[1]

For the 2028 Energy Code development process, a new approach to developing the weather data files was implemented. This approach incorporates Global Climate Models (GCMs) created by international climate scientists to predict future weather patterns and parameters. This work relied upon the climate data and tools available from Cal-Adapt. Cal-Adapt was developed by Eagle Rock Analytics and the Geospatial Innovation Facility at the University of California, Berkeley, with support from the Lawrence Berkeley National Lab. The California Energy Commission provided funding and advisory oversight.[2] Please see “About Climate Projections and Models” for more information.[3] In order to account for the effects of changing climate conditions in the future, new weather files have been generated to support the 2028 Energy Code development process using this new methodology. These files are referred to in this report as “future weather files.”

This report describes the scope of the future weather files included in the update, the details of the methodology used to update the weather files, and the energy impacts associated with the updates for single-family residential and commercial buildings. The forthcoming 2028 update to weather files,

---

[1] Wilcox, Bruce A. *Weather Files and Climatic Data for the 2025 Standards*. April 2023.

[2] Cal-Adapt. 2025. https://cal-adapt.org/

[3] Cal-Adapt. 2025 “About Climate Projections and Models”. https://analytics.cal-adapt.org/guidance/about_climate_projections_and_models/

prototypes, plug loads and the LSC and Source Energy metrics will only apply to nonresidential building types.

Weather Data Update Scope

The primary focus of the weather data updates was to create future weather files for potential use in evaluating updates to the Title 24 Energy Code for 2028. Future weather files based on weather data collected in a representative city within each of the 16 CA climate zones were developed.

These 16 weather files are also used to derive the LSC and Source Energy metrics, along with other data such as power plant operational data, greenhouse gas emissions data, and renewable generation data.

After adoption of the 2028 Energy Code, the CA weather files also serve as inputs to the compliance software for analysis using the Energy Code's performance path. The compliance analysis relies on a larger set of CA weather files. Multiple weather files are created for each climate zone to better represent location-dependent variations in weather patterns within each climate zone. 117 additional CA weather files were created to support adoption of the 2025 code. If the future weather file methodology is adopted, these additional files will need to be created for 2028.

California Climate Zone Locations

Each California climate zone's weather data is derived from a representative city. These cities, and their associated climate zone, are listed below.

California climate zone weather station locations:

- CZ1: California Redwood Coast Humboldt County Airport (ACV)
- CZ2: Sonoma County Airport (STS)
- CZ3: Metro Oakland International Airport (OAK)
- CZ4: Paso Robles Airport (PRB)
- CZ5: Santa Maria Airport (SMX)
- CZ6: Los Angeles International Airport (LAX)
- CZ7: San Diego International Airport (SAN)
- CZ8: Fullerton Municipal Airport (FUL)
- CZ9: Hollywood Burbank Airport (BUR)
- CZ10: Riverside Municipal Airport (RAL)
- CZ11: Red Bluff Airport (RBL)
- CZ12: Sacramento Executive Airport (SAC)
- CZ13: Fresno Yosemite International Airport (FAT)
- CZ14: Palmdale Regional Airport (PMD)

- CZ15 Palm Springs International Airport (PSP)
- CZ16: Blue Canyon Nyack Airport (BLU)

Methodology for Developing Historic Weather Files

This section describes the traditional approach for developing typical weather data based on past conditions, as used during the development of the 2025 TMY weather files. This will provide important context for understanding the new methodology (described in the section Methodology for Developing Future Weather Files).

The process for developing the weather files begins with selecting the period of analysis, then using data from the selected years to determine the "typical" annual conditions. This process is described in the following sections.

Selection of Weather Years

TMY files are generally based on at least 20 years of recent weather data. The updates to the TMY files for the 2025 code update were based on the years 2000-2020 (inclusive), representing a period of 21 years. The year 2000 was chosen as the starting point because there is a lack of photovoltaic (PV) energy production data prior to 2000, and this is a key set of data for the LSC metric analysis.

Determining "Typical" Weather Conditions

A significant set of hourly data is collected at each of the chosen weather stations including, but not limited to, dry bulb and wet bulb temperature, solar radiation, cloud cover, wind data, and precipitation. Meteorological data are provided by NOAA's Integrated Surface Database (ISD)[4] while solar data are provided from NREL's National Solar Radiation Database (NSRDB) Physical Solar Model (PSM) version 3.[5]

[4] Smith, Adam, Neal Lott, and Russ Vose. "The Integrated Surface Database: Recent Developments and Partnerships." Bulletin of the American Meteorological Society 92, no. 6 (June 1, 2011): 704–8. https://doi.org/10.1175/2011BAMS3015.1.

[5] Sengupta, Manajit, Yu Xie, Anthony Lopez, Aron Habte, Galen Maclaurin, and James Shelby. "The National Solar Radiation Data Base (NSRDB)." Renewable and Sustainable Energy Reviews 89 (June 2018): 51–60. https://doi.org/10.1016/j.rser.2018.03.003.

For each of the 21 years of weather data included in the analysis, a month-by-month analysis is first performed using the standard "TMY3" procedures.[6] Starting with January, all 21 Januarys are investigated and the one found most "typical" is selected as described below. This process is repeated for each month to select representative monthly data for all 12 months. Because the data from adjacent months is rarely from the same year, the data is blended for 6 hours on each side of the month boundary.

The TMY3 methodology consists of evaluating 10 indices (see Table 1). For a given month and a given station/location, each index is calculated for all 21 years. The long-term, 21-year cumulative frequency distribution (CDF) of a given index is calculated and compared to each individual year's CDF through the Finkelstein-Shafer (FS) statistic[7] which is a measure of agreement between two distributions. For a given station, a weighted sum of all FS statistics for each index is calculated. If the TMY was to be determined at the individual station level, the year with the corresponding smallest overall FS would be selected.

Table 1 - TMY Weights

Dry-Bulb	Dry-Bulb	Dry-Bulb	Dewpoint	Dewpoint	Dewpoint	Wind Speed	Wind Speed	Global Horizontal Insolation	Direct Normal Insolation
Min	Avg	Max	Min	Avg	Max	Avg	Max	Avg	Avg
5.0%	10.0%	5.0%	5.0%	10.0%	5.0%	5.0%	5.0%	25.0%	25.0%

However, the goal of this project is to provide a time-coincident TMY for California state-wide. For each month and each year, the state-wide FS statistic is calculated by a weighted sum of each station, with the station weights determined by the population of the corresponding climate zone (see Table 2). The result is a matrix of year × month FS statistic representing California (see Figure 1).

[6] Wilcox, S, and W Marion. "Users Manual for TMY3 Data Sets." Golden, CO: National Renewable Energy Laboratory, May 2008.

[7] Finkelstein, J. M., and R. E. Schafer. 1971. "Improved Goodness-of-Fit Tests." Biometrika 58 (3): 641–45. https://doi.org/10.1093/biomet/58.3.641.

Table 2 - Location/Population Weights

Location	Weight
CZ1 Arcata	0.5%
CZ2 Sonoma County	2.4%
CZ3 Oakland	9.7%
CZ4 Paso Robles	5.1%
CZ5 Santa Maria	1.0%
CZ6 Los Angeles	7.3%
CZ7 San Diego	5.7%
CZ8 Fullerton	11.3%
CZ9 Burbank	15.2%
CZ10 Riverside	12.6%
CZ11 Red Bluff	3.1%
CZ12 Sacramento	13.1%
CZ13 Fresno	6.9%
CZ14 Palmdale	2.7%
CZ15 Palm Springs	2.2%
CZ16 Blue Canyon	1.3%

Figure 1 - Finkelstein-Shafer Statistic for all of California. Circles represent the minimum FS year for each month and thus the selected TMY years.

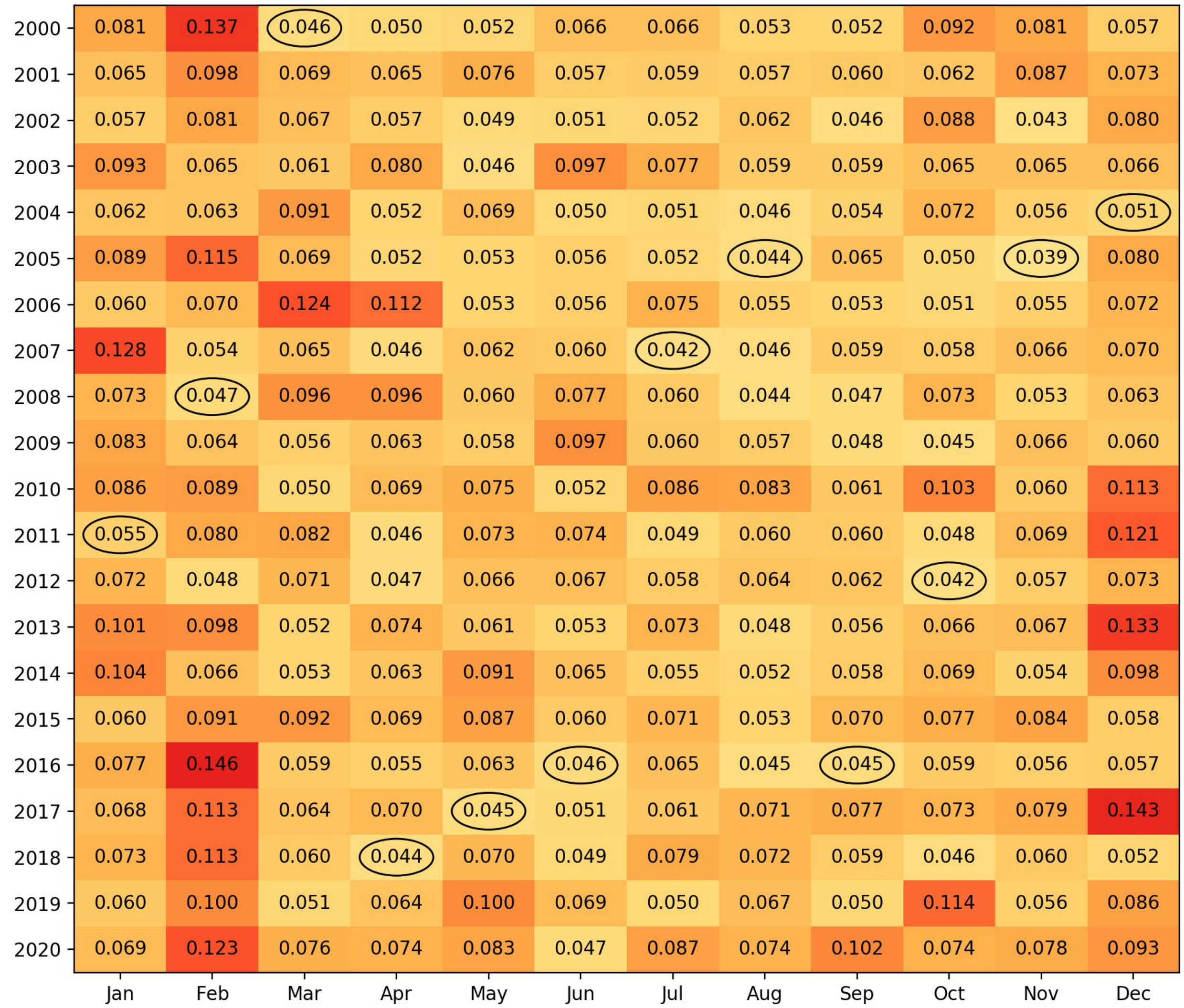


Table 3 summarizes the monthly data used to define the 2025 typical weather data.

Table 3 - Weather Year Selection of TMY Months

Month	Weather Year
1	2011
2	2008
3	2000
4	2018

Month	Weather Year
5	2017
6	2016
7	2007
8	2005
9	2016
10	2012
11	2005
12	2004

Methodology for Developing Future Weather Files

The methodology for developing the future weather data files follows a similar approach to the TMY development approach, but rather than selecting from historic weather years that represent typical monthly weather, historic weather years are selected that best represent future weather projections.

The process included analyzing the most appropriate future weather scenario projections, determining a process to use the projections to derive predicted monthly weather targets, and then selecting from the historical monthly data that best aligns with the projected weather targets. This process is described in the following sections.

Assessment of Future Weather Models

The evaluation process aimed to identify a data source that included the appropriate data points needed to generate weather files, and climate change scenarios appropriate for California policymaking. Climate change scenarios are developed by the international community under the auspices of the International Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change. Two sets of high-resolution climate model data sources were evaluated for this project: the

Weather Research and Forecasting model (WRF)[8], and the Localized Constructed Analogs model (LOCA2).[9] [10]

Ultimately, the LOCA2 dataset was chosen for use in developing the future weather files as discussed in the following sections.

Evaluation of WRF

WRF is a numerical weather model that is dynamically downscaled to provide high-resolution data. A key benefit of the WRF dataset for the purpose of developing weather files is that it outputs data at an hourly resolution, and could be used directly for building simulations.

Additionally, because it is a numerical weather model, it contains all of the variables needed for the building simulation weather files such as temperature, solar radiation, and wind data. Because it is all contained in a single model, these variables are all consistent with each other. For example, a hot clear day versus a cloudy day will each have solar radiation variables that align appropriately. The methodology used for the traditional TMY weather file development (see Methodology for Developing Historic Weather Files) uses meteorological data and solar data from different sources and may not align perfectly.

The following section describes comparisons of key weather indicators for Sacramento (CZ 12) in July.

WRF Dry Bulb Data

Figure 2 illustrates a comparison of dry bulb temperature from observational data (blue line) to each of the GCMs (solid lines).[11] Two key takeaways are:

- The time of the peak dry bulb temperature occurs earlier in the day by approximately 1 hour for all the models than for the observational data.

---

[8] Rahimi, Stefan, Lei Huang, Jesse Norris, Alex Hall, Naomi Goldenson, Will Krantz, Benjamin Bass, et al. 2024. "An Overview of the Western United States Dynamically Downscaled Dataset (WUS-D3)." Geoscientific Model Development 17 (6): 2265–86. https://doi.org/10.5194/gmd-17-2265-2024.

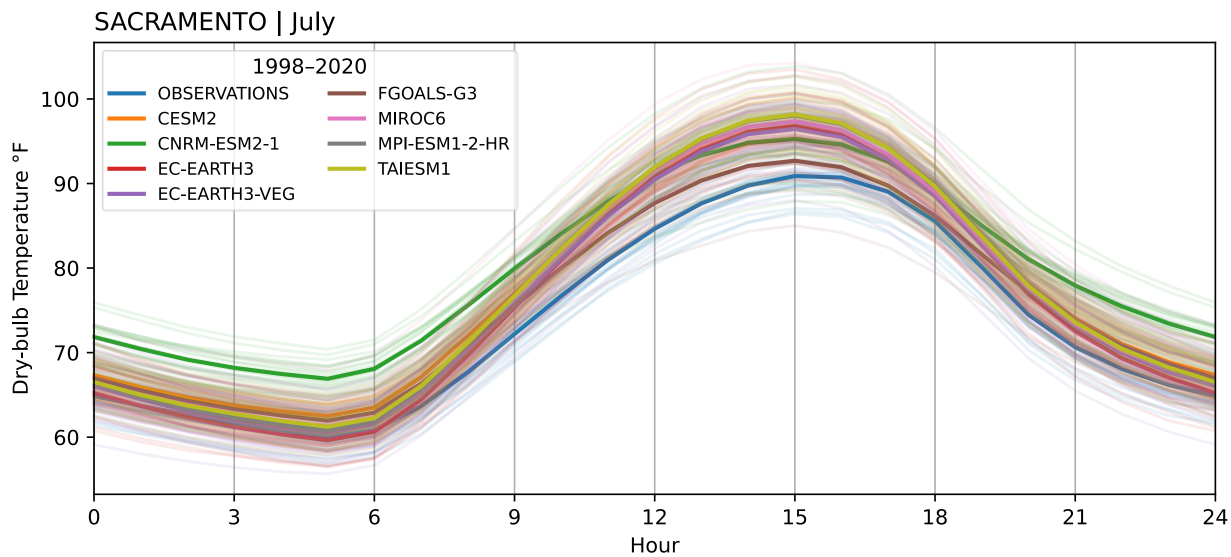
[9] Pierce, David W., Daniel R. Cayan, Daniel R. Feldman, and Mark D. Risser. 2023. "Future Increases in North American Extreme Precipitation in CMIP6 Downscaled with LOCA." Journal of Hydrometeorology 24 (5): 951–75. https://doi.org/10.1175/JHM-D-22-0194.1.

[10] Cal-Adapt. 2025 "About Climate Projections and Models". https://analytics.cal-adapt.org/guidance/about_climate_projections_and_models/

[11] Note that the shaded lines represent each year of annual data, and the solid lines represent averaged data.

- The shape of the curves was quite similar, but there is a bias in the curves where the modeled data is shifted up compared to the observational data.

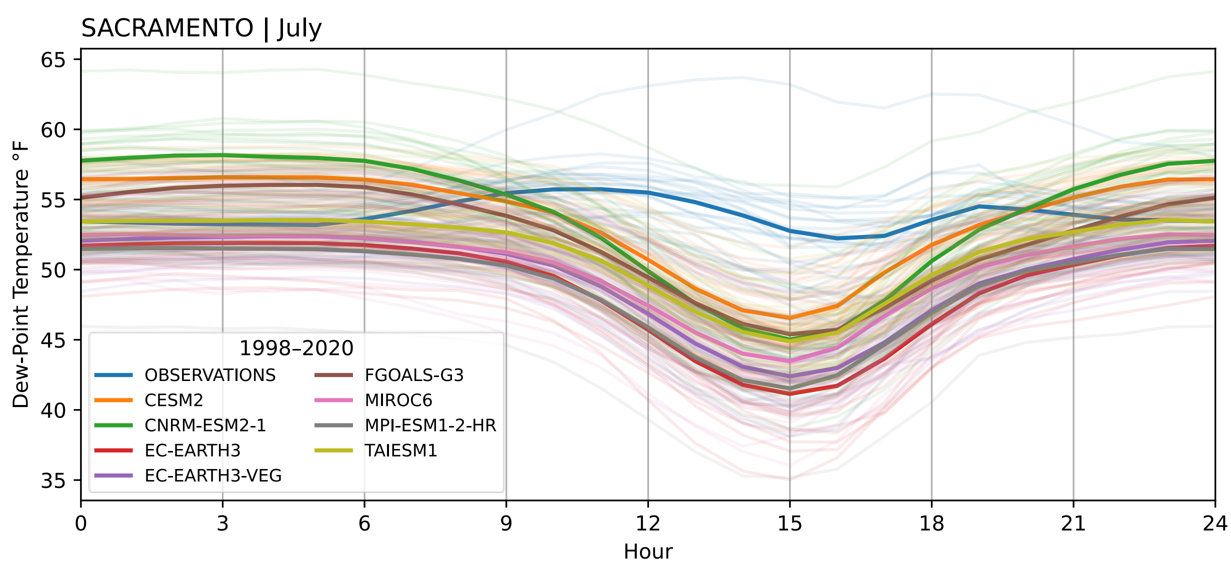
Figure 2 - Screening of WRF Dry Bulb Data



WRF Dew Point Data

Figure 3 illustrates a comparison of dew point temperature from observational data to each of the GCMs. In this case, the models' due point profile is very different from the observational data.

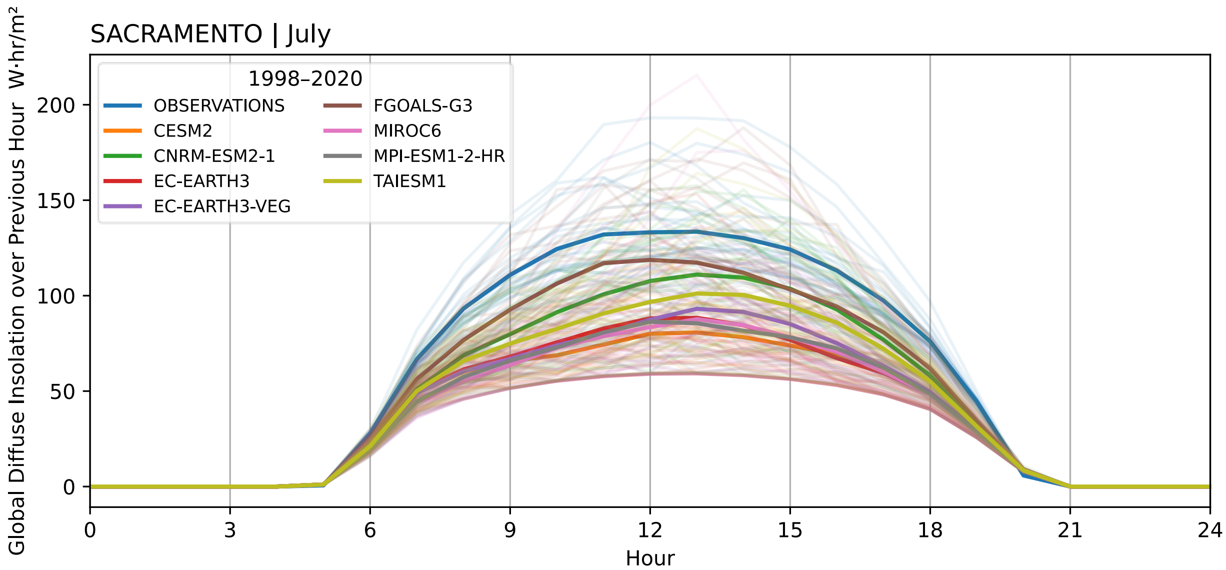
Figure 3 - Screening of WRF Dew Point Data



WRF Solar Data

Figure 4 illustrates the differences between the diffuse component of insolation between the observational and GCM data. Many of the GCM models overpredict the occurrence of clear sky conditions (i.e., without clouds) and therefore have consistently lower diffuse insolation.

Figure 4 - Screening of WRF Diffuse Insolation Data



WRF Data Analysis Conclusions

As noted, the nature of the hourly WRF data makes it an excellent candidate for use in the development of the building simulation weather files. However, after reviewing the available data it was determined that WRF is not yet appropriate to use because there are significant differences between the WRF data and observational data between 1998-2020.

Evaluation of LOCA2

The LOCA2 downscaling methodology includes more future climate prediction scenarios and additional weather variables compared to WRF.

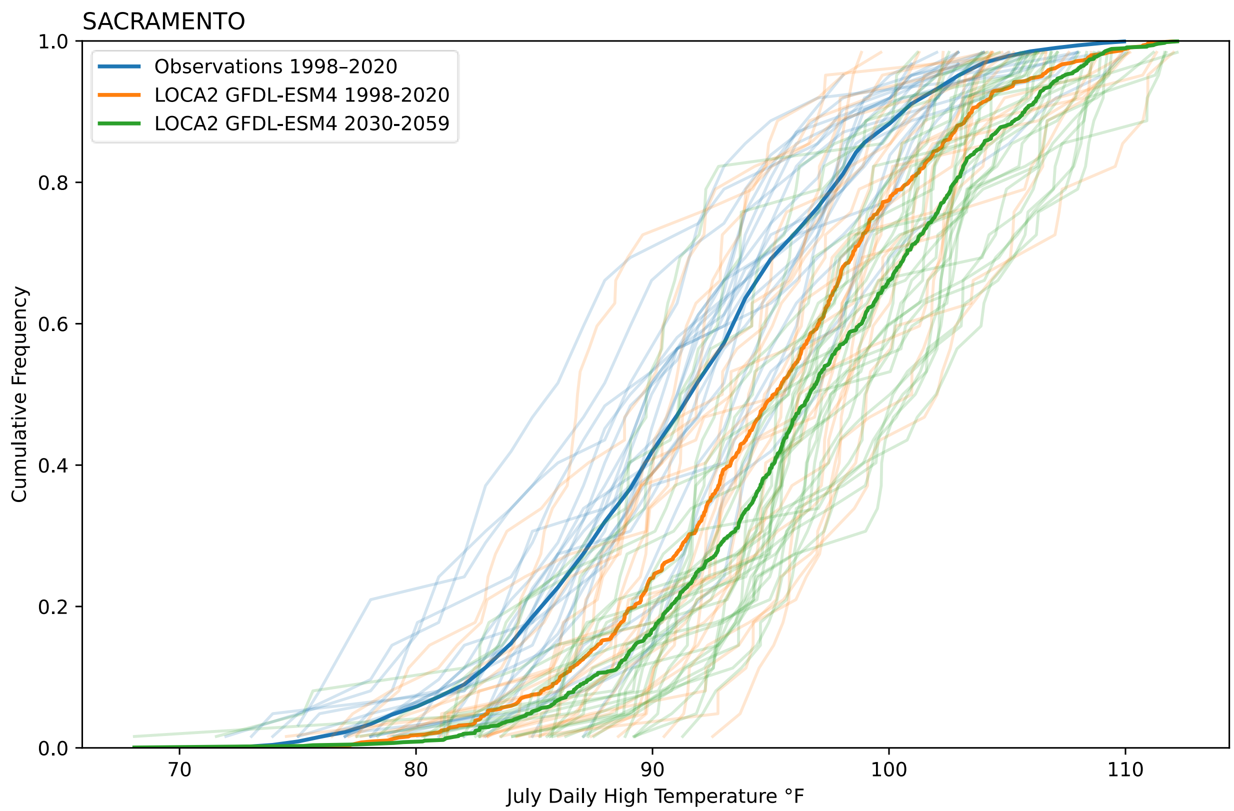
The LOCA2 data produces daily averages of the climatic variables so it cannot be used directly in building simulations without performing additional analysis to generate hourly data. However, the TMY process relies on daily values when plotting CDFs, so the LOCA2 data is appropriate for this purpose.

The team assessed using the LOCA2 data as a climate signal to choose months from the 1998 to 2020 data sets that are closest to a LOCA2 target. This approach is described in detail in the subsequent sections for Sacramento (CZ 12) in July.

LOCA2 Temperature Data

Figure 5 is a Cumulative Distribution Function (CDF) that illustrates a comparison of the observational data (blue line) for daily high temperature to the LOCA2 data over the same period (orange line). Additionally, the green line represents the targeted future period 2030-2059. In a CDF plot, each point represents the probability that a specific value will be below a target value. Each faded line represents an individual year from the data, and the solid lines represent the average values for the full dataset. Because the LOCA2 data is based on a model, differences from the observational data are expected but the overall shape of the CDF curves are quite similar. These differences need to be bias corrected.

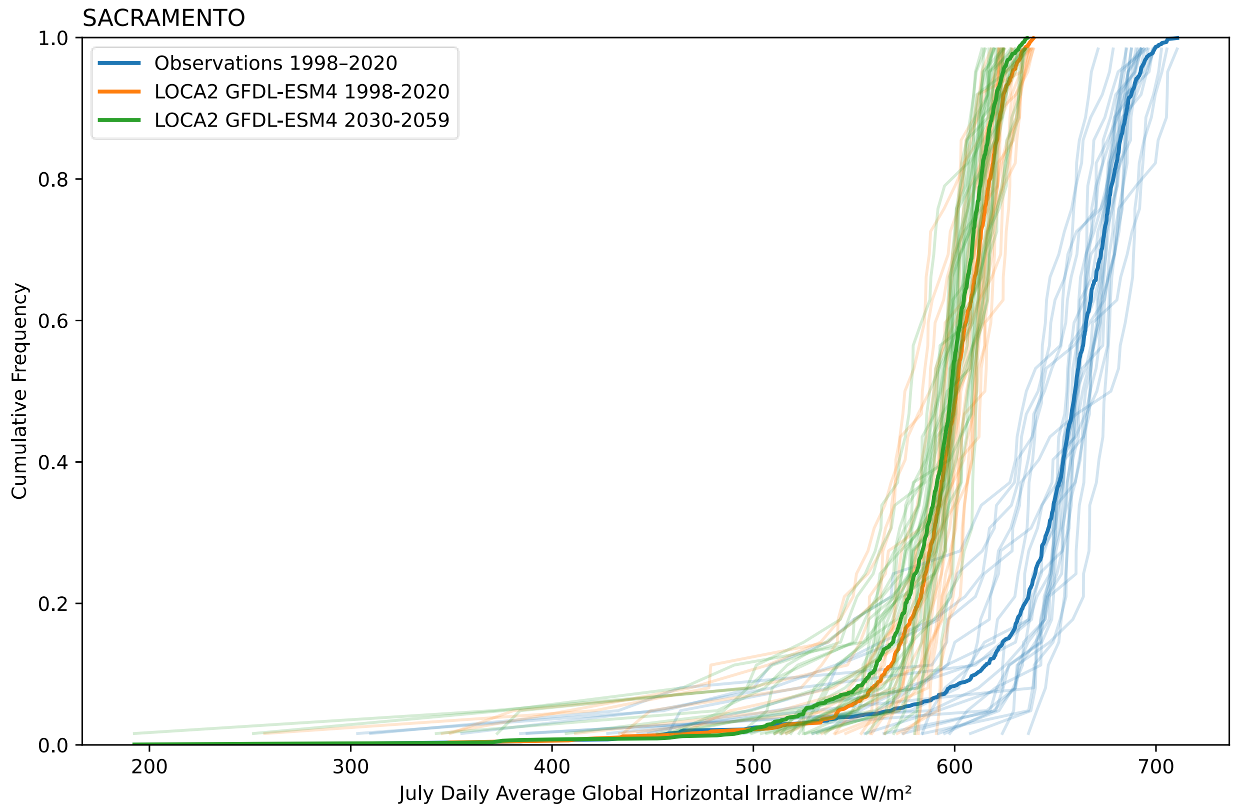
Figure 5 - Screening of LOCA2 Daily High Temperature Data for July



LOCA2 Solar Data

Review of the LOCA2 solar data compared with observational data shows a similar agreement in the shape of the curves but a need for bias correction as illustrated in Figure 6.

Figure 6 - Screening of LOCA2 Solar Data for July



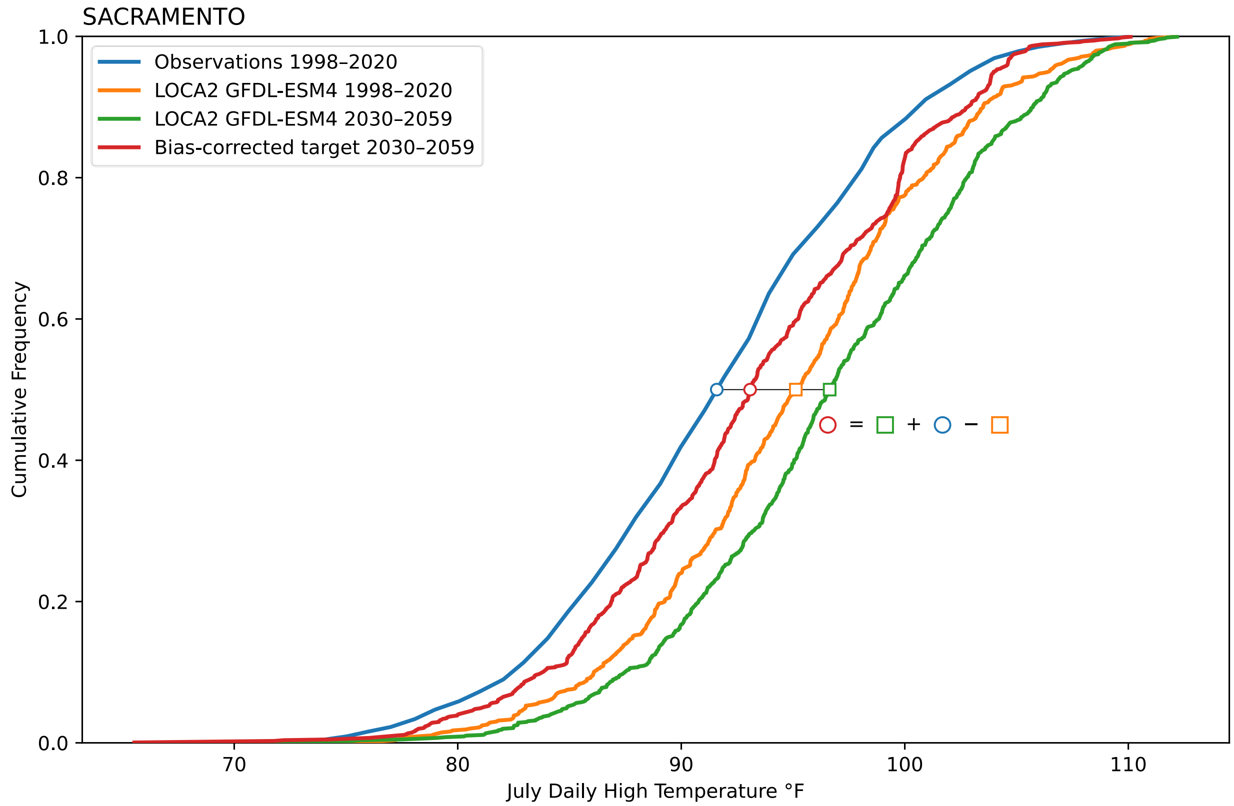
Bias Correction Approach for LOCA2 Data

A widely-used technique for bias correction called the delta-quantile-mapping approach was used to address the alignment issues of the observational data with the LOCA2 model data over the same period. This process allows the data to be calibrated in order to create a shifted version of the future data.

Figure 7 illustrates this process where a median point on the curve is chosen and a simple equation is used to determine the bias-corrected target curve. The future LOCA2 data (green line) is added to the difference between the observed historical data (blue line) and the LOCA2 historical data (orange line) to determine the bias-corrected target curve (red line).

This bias-correction process[12] was applied to the key weather variables needed for the TMY files including daily high temperatures, solar values, and wind speeds.

Figure 7 - Delta-Quantile Mapping of LOCA2 Data for July



The team decided to use the LOCA2 data as the bias-correction is straightforward to implement.

The following sections describe how the bias-corrected LOCA2 data was used to develop the future weather files.

Creating the Future Weather Files

The next stage of the project was to use the bias-corrected future weather data targets as the basis for performing a month-by-month selection of historical observational data that best aligns with the future

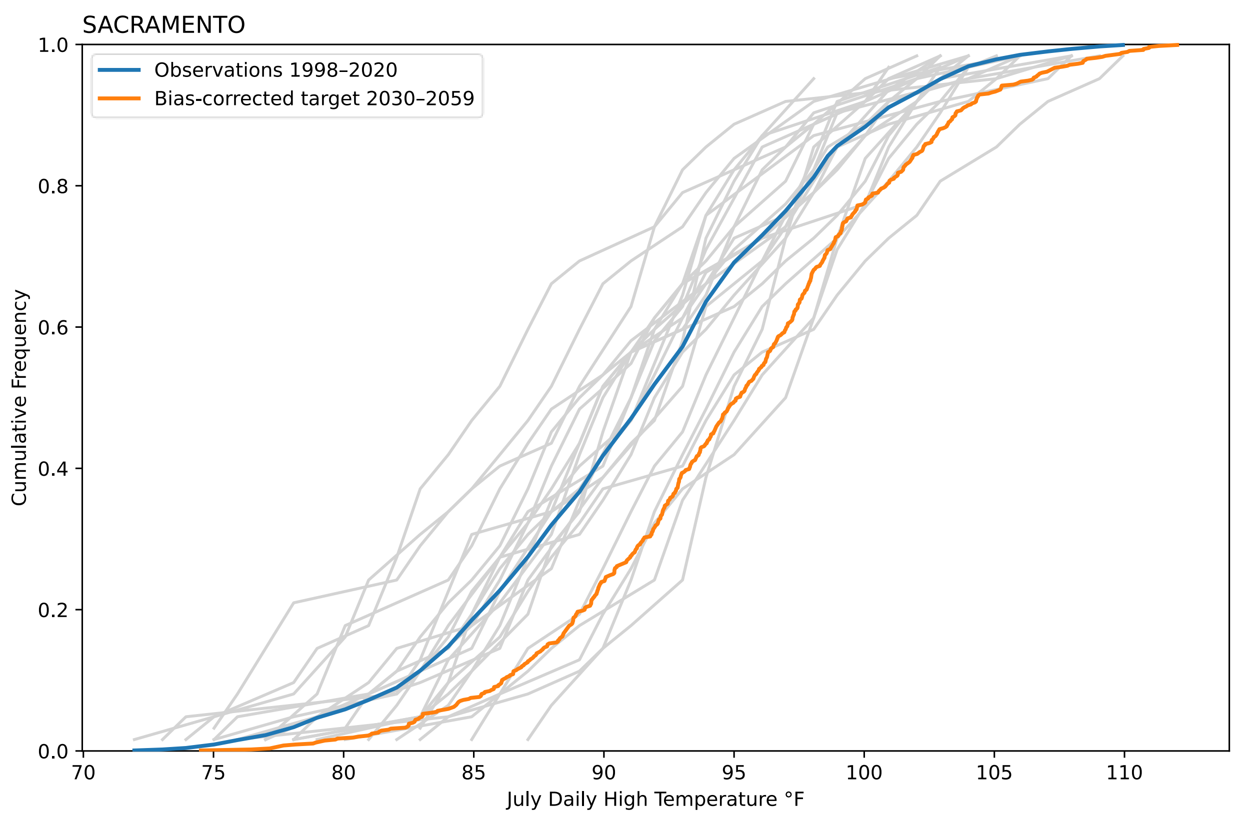
[12] See https://analytics.cal-adapt.org/guidance/about_climate_projections_and_models/ for discussion of bias correction.

weather targets, following the same procedures as used in past TMY file development. The key difference between the 2025 process for developing historic weather files and the new process for developing future weather files is that, instead of using a target of the 2000-2020 climatological CDF, the LOCA2 data for 2030-2059 are used to shift the target; but all the yearly 1998-2020 data sets are still used for selecting the most appropriate TMY monthly data.

Figure 8 illustrates an example of this process for July high temperatures in Sacramento (CZ 12). The blue line represents an average of all the historical observational data, and the orange line represents the future weather target found by bias-correcting each GCM model in turn and averaging. Each gray line represents a single year's available historical observational data from which to choose.

There are a limited number of historical observational data curves that are close to this new target, as the future weather is more likely to look like outlier conditions from past years.

Figure 8 - Comparison of Observational Data to Target for July



Revised TMY Weighting Scheme

The LOCA2 data has some limitations with data availability compared to variables needed in the TMY files. Some missing elements include daily high and low dew point temperatures (only average dew point is available). Solar data is only available as global horizontal insolation (no direct horizontal insolation data is available) and wind speed data only includes average wind speed (no maximum wind speed is available). As a result, the traditional TMY weighting of variables used to select weather years was revised to account for these missing elements. The revisions intended to maintain the same overall weights compared to 2025, but some variables were collapsed together due to the data limitations. A comparison of the 2025 and 2028 weightings are shown in Table 4.

Table 4 - Comparison of 2025 and 2028 TMY Variable Weights

Edition	Dry-Bulb Min	Dry-Bulb Avg	Dry-Bulb Max	Dewpoint Min	Dewpoint Avg	Dewpoint Max	Wind Speed Avg	Wind Speed Max	Global Horizontal Insolation Avg	Direct Normal Insolation Avg
2025	5.0%	10.0%	5.0%	5.0%	10.0%	5.0%	5.0%	5.0%	25.0%	25.0%
2028	5.0%	10.0%	5.0%	-	20.0%	-	10.0%	-	50.0%	-

Selection of Weather Years

The CDF curves indicate that future temperatures will be warmer, and indeed the selections of representative years for monthly data were from warmer years than the mid-range years selected for the 2025 weather files.

Figure 9 shows that the selected (circled) values are closer to the end of the periods where hotter years are selected. Also noteworthy is that the two years for June and July are from 2006 when there was a large North American heat wave. This highlights that not only warmer years are expected, but also that normal weather conditions in the future may more closely resemble current “extreme” conditions.

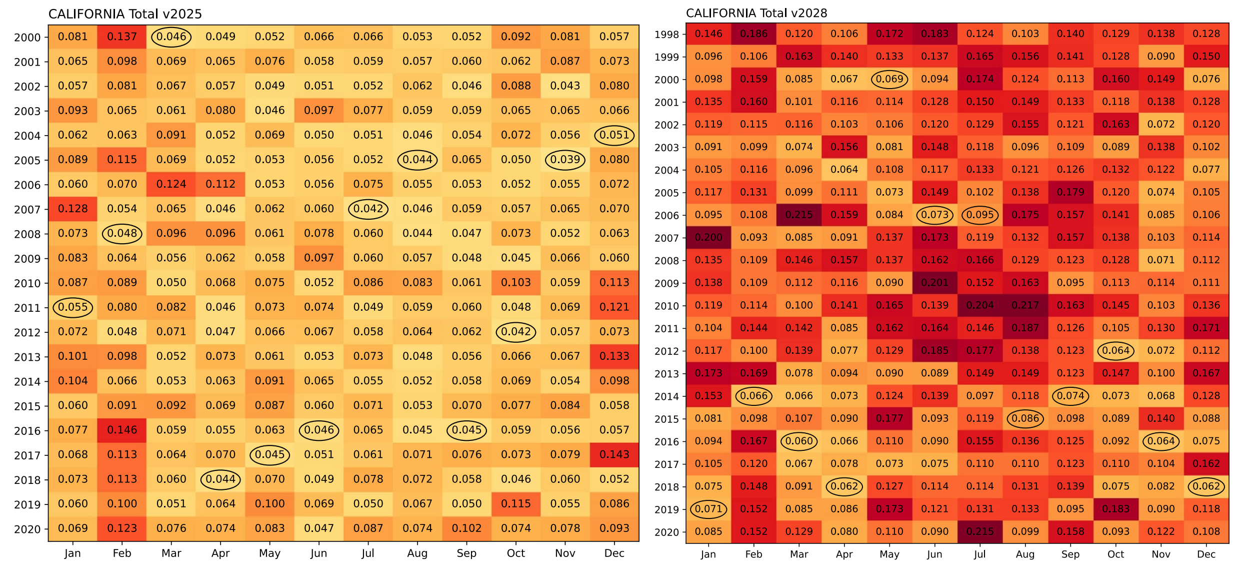
Figure 10 shows a comparison of the decision matrices from 2025 and 2028. The figure shows that the colors for the 2028 selections have gotten darker. The darkness of each cell represents the distance of all the individual years to the target. Since the 2028 target has been pushed off to the right (see Figure 8), all the historical observational curves to the left have become further away from the target and thus the cells (in Figure 9) have become darker.

Figure 9 - Finkelstein-Shafer Statistic for Future Weather Data

CALIFORNIA Total v2028

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	0.146	0.186	0.120	0.106	0.172	0.183	0.124	0.103	0.140	0.129	0.138	0.128
1999	0.096	0.106	0.163	0.140	0.133	0.137	0.165	0.156	0.141	0.128	0.090	0.150
2000	0.098	0.159	0.085	0.067	0.069	0.094	0.174	0.124	0.113	0.160	0.149	0.076
2001	0.135	0.160	0.101	0.116	0.114	0.128	0.150	0.149	0.133	0.118	0.138	0.128
2002	0.119	0.115	0.116	0.103	0.106	0.120	0.129	0.155	0.121	0.163	0.072	0.120
2003	0.091	0.099	0.074	0.156	0.081	0.148	0.118	0.096	0.109	0.089	0.138	0.102
2004	0.105	0.116	0.096	0.064	0.108	0.117	0.133	0.121	0.126	0.132	0.122	0.077
2005	0.117	0.131	0.099	0.111	0.073	0.149	0.102	0.138	0.179	0.120	0.074	0.105
2006	0.095	0.108	0.215	0.159	0.084	0.073	0.095	0.175	0.157	0.141	0.085	0.106
2007	0.200	0.093	0.085	0.091	0.137	0.173	0.119	0.132	0.157	0.138	0.103	0.114
2008	0.135	0.109	0.146	0.157	0.137	0.162	0.166	0.129	0.123	0.128	0.071	0.112
2009	0.138	0.109	0.112	0.116	0.090	0.201	0.152	0.163	0.095	0.113	0.114	0.111
2010	0.119	0.114	0.100	0.141	0.165	0.139	0.204	0.217	0.163	0.145	0.103	0.136
2011	0.104	0.144	0.142	0.085	0.162	0.164	0.146	0.187	0.126	0.105	0.130	0.171
2012	0.117	0.100	0.139	0.077	0.129	0.185	0.177	0.138	0.123	0.064	0.072	0.112
2013	0.173	0.169	0.078	0.094	0.090	0.089	0.149	0.149	0.123	0.147	0.100	0.167
2014	0.153	0.066	0.066	0.073	0.124	0.139	0.097	0.118	0.074	0.073	0.068	0.128
2015	0.081	0.098	0.107	0.090	0.177	0.093	0.119	0.086	0.098	0.089	0.140	0.088
2016	0.094	0.167	0.060	0.066	0.110	0.090	0.155	0.136	0.125	0.092	0.064	0.075
2017	0.105	0.120	0.067	0.078	0.073	0.075	0.110	0.110	0.123	0.110	0.104	0.162
2018	0.075	0.148	0.091	0.062	0.127	0.114	0.114	0.131	0.139	0.075	0.082	0.062
2019	0.071	0.152	0.085	0.086	0.173	0.121	0.131	0.133	0.095	0.183	0.090	0.118
2020	0.085	0.152	0.129	0.080	0.110	0.090	0.215	0.099	0.158	0.093	0.122	0.108

Figure 10 - Comparison of 2025 and 2028 Finkelstein-Shafer Statistics



Evaluation of Future Weather Data Files

After assembling the new TMY files from the monthly data, a final validation was performed. The validation process was performed by reviewing the cooling and heating degree days between the historical observational data, bias-corrected LOCA2 data, and the generated future weather TMY file data.

Figure 11 illustrates this process for climate zone 12 (Sacramento). In this plot:

- The gray lines represent the bias-corrected LOCA2 historical data
- The orange lines represent the bias-corrected future weather projected data
- The black line represents the 1998-2020 historical observational data
- The green dashed line represents the average degree days for the 2025 TMY file
- The blue line represents the average degree days for the newly created 2028 TMY file

There are several key insights from this analysis. There is an upward trend in cooling degree days and a downward trend in heating degree days as expected. The average for the 2025 TMY degree days falls about in the middle of the 1998-2020 observational data (black line). The average for the 2028 TMY degree days is contained within the LOCA2 2030-2059 data, but not exactly in the middle. However, this is to be expected for a few reasons. The 2028 TMY data was derived not just from temperature data, but also from other variables such as dew point and solar data, and also the TMY data is derived across all of the climate zones based on population weighting. Therefore, the average line will not fall directly in the middle of the LOCA2 data. This analysis is consistent in most other climate zones. Figure 12 illustrates the analysis for climate zone 9 (Burbank).

Figure 11 - Degree Day Validation (Climate Zone 12)

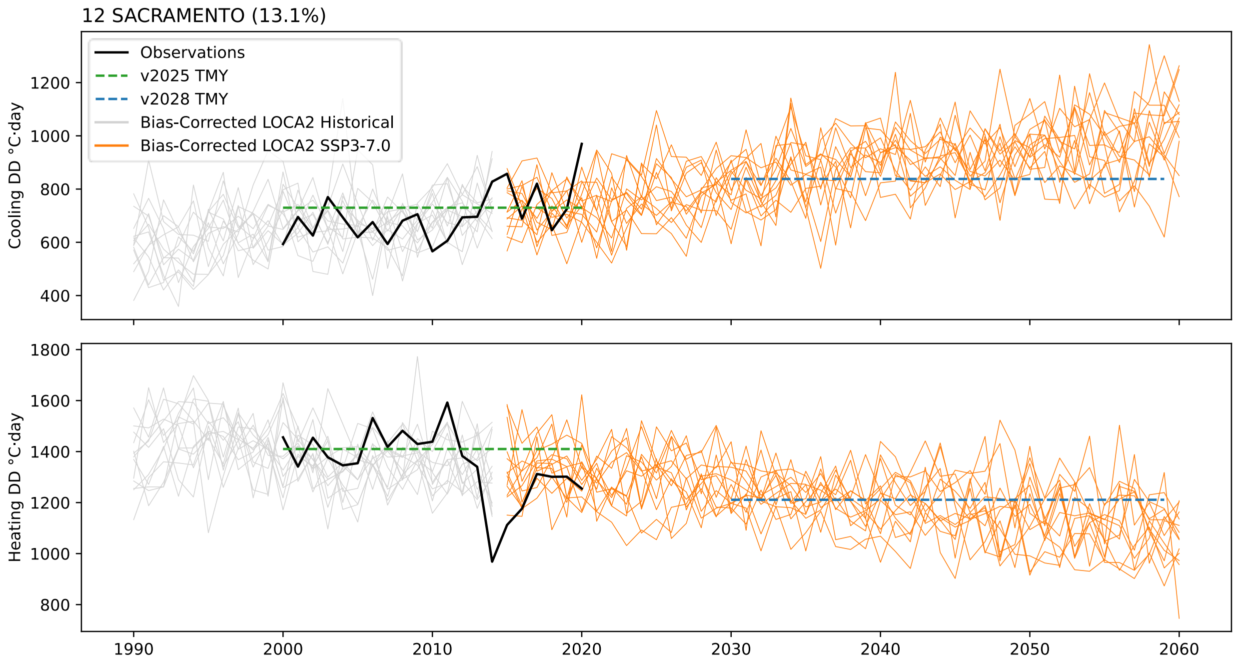
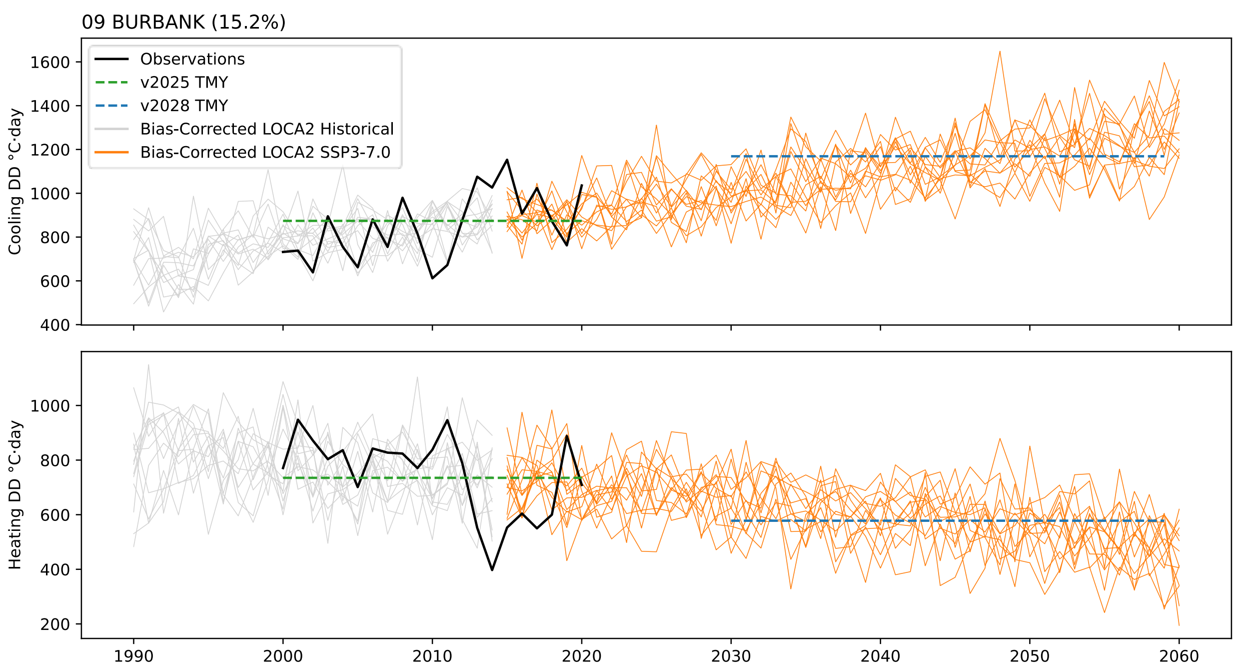
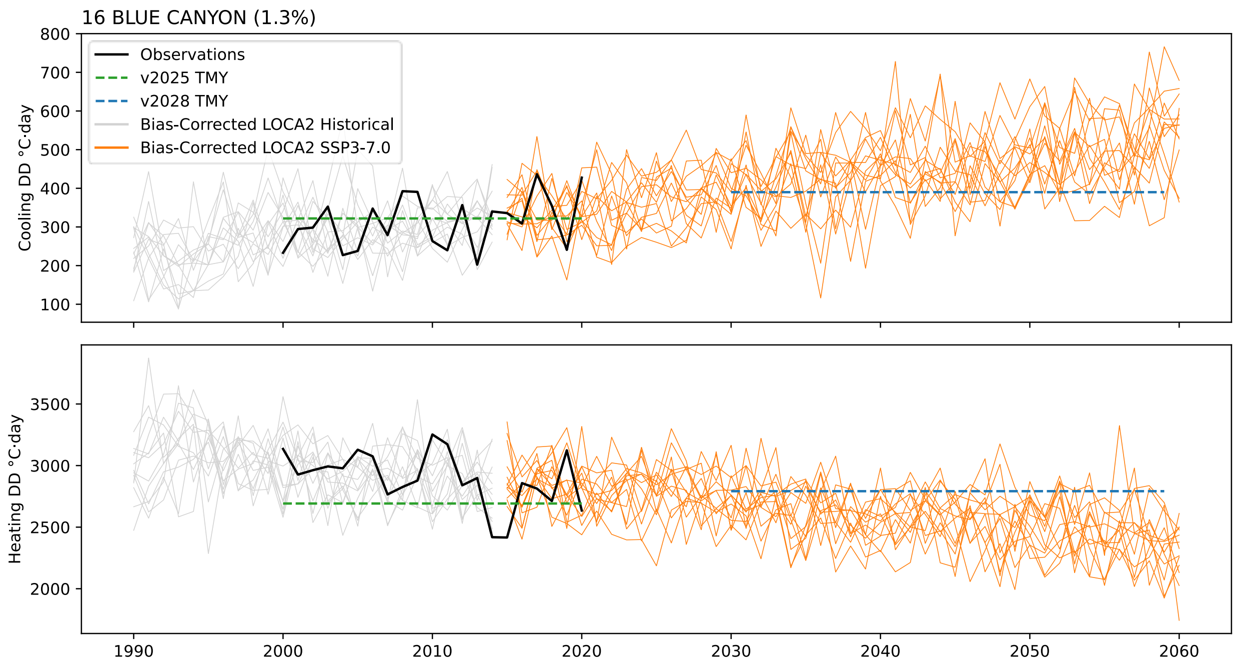


Figure 12 - Degree Day Validation (Climate Zone 09)



Climate zone 16 was the one outlier in this analysis. Figure 13 shows that there is an increase in cooling degree days, as expected, but also an increase in heating degree days, which is unique to this climate zone's TMY data. The reasons for this increase in heating degree days can be explained by the very low population weighting of climate zone 16 (see Table 2). If Blue Canyon is cold when the rest of the state is hot, then the selected weather year may not result in a good fit for this location. This phenomenon was also present in the 2025 TMY heating degree data as shown by the green dashed line falling near the edge of the observational data.

Figure 13 - Degree Day Validation (Climate Zone 16)



Analysis and Comparison of Energy Impacts Between Future and Historic Weather Files

Upon completing the development of the future weather files, an analysis was performed to assess how the future weather data would impact energy consumption estimates compared to the historic weather data used in the 2025 Energy Code. This analysis was done by running whole-building energy model simulations of prototype models representing a single-family, 2,700 square foot residential home, and a medium-sized (approximately 50,000 square foot) office building. The prototypes both met the prescriptive requirements of the 2022 energy code with electric heat pump heating in the residential home and gas heating in the office.

These prototype models were chosen due to their prevalence in predicted newly constructed buildings in the coming years, and because they serve as a good indicator of how performance with the new weather data may be impacted for both residential and commercial buildings. The forthcoming 2028 update to weather files, prototypes, plug loads and the LSC and Source Energy metrics will only apply to nonresidential building types.

The prototype models were generated using the CEC's compliance software tools, CBECC-Res (for the residential prototype) and CBECC (for the commercial prototype).

Simulations were run for each prototype in each climate zone using both the 2025 historic weather files and the future weather files.

Figure 14 illustrates the comparison of annual energy consumption for cooling and heating for the single-family residential prototype. The results show an increase in cooling for all climate zones and a decrease in heating for all climate zones except climate zone 16.

Figure 15 illustrates the comparison of annual energy consumption for cooling and heating for the medium office prototype. The results are consistent with the residential prototype, again showing an increase in cooling for all climate zones and a decrease in heating for all climate zones except climate zone 16.

Figure 14 - Energy Use Comparison (Single-Family Prototype)

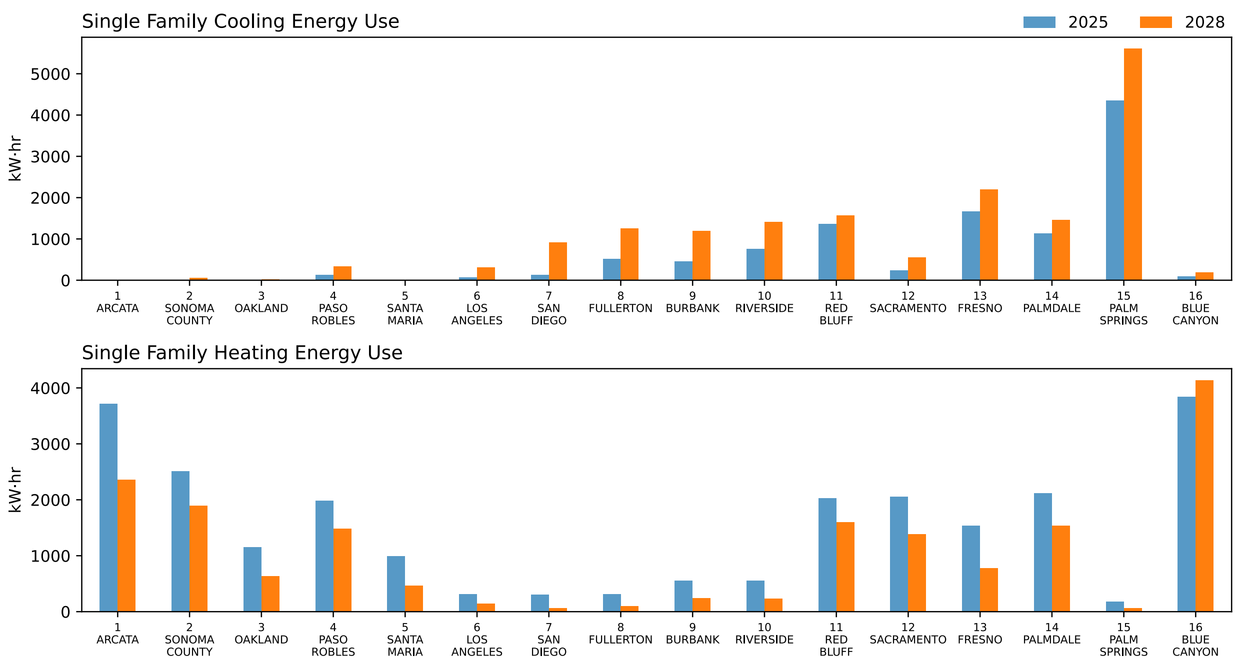
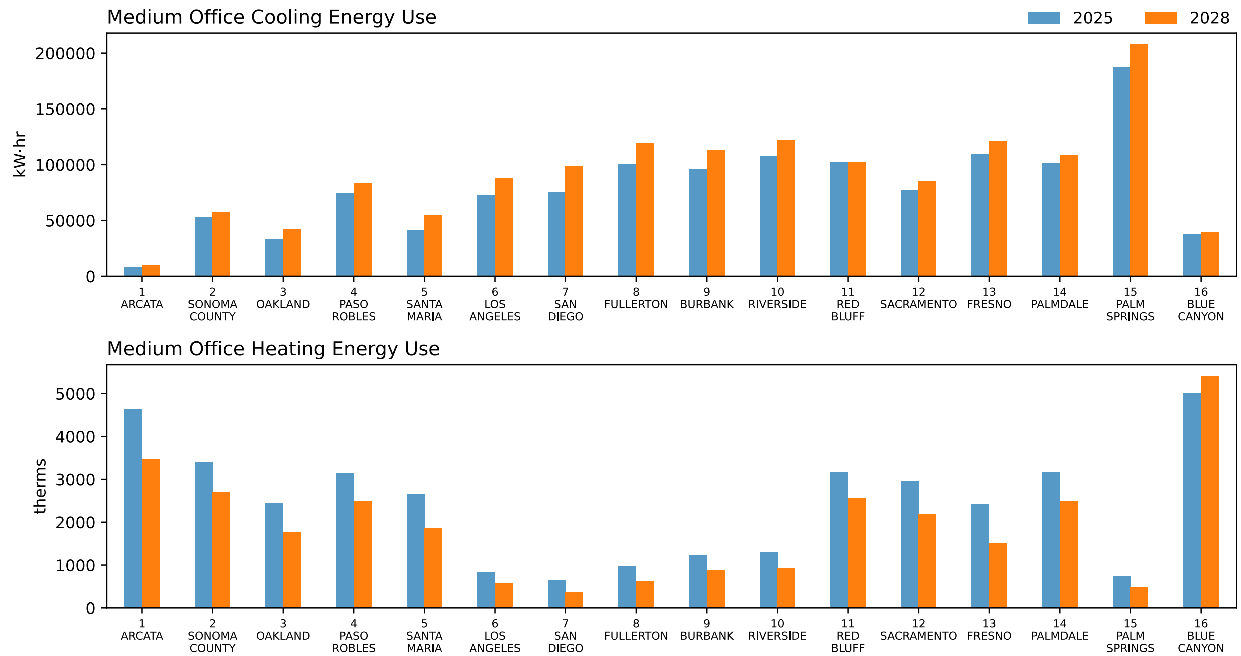


Figure 15 - Energy Use Comparison (Medium Office Prototype)



Conclusions and Considerations for Future Work

The approach used to generate the future weather TMY files provides results that align with expected outcomes, and would serve as a good basis for accounting for future changes to the climate in assessing energy efficiency measures used for compliance with the Energy Code.

The LOCA2 model data has some limitations, especially with variables such as solar, cloud cover, and dewpoint temperatures. But, the models continue to improve over time so future updates will continue to result in greater reliability of results.

Finally, although WRF data was not the chosen model, it should continue to be reviewed in the future. WRF has better information on longwave radiation that is a very important factor in building performance. It also allows for more granular localization than LOCA2 which relies on a limited number of observational weather station locations. As the WRF model improves in the future and addresses the bias correction issues, it could become the preferred model for future iterations of this work.

Appendix: Weather Files Created

The weather files include the following header information:

Climate Zone - LOCATION – Weather Station - WBAN[13]

1	Arcata,CA,USA,California Redwood Coast Humboldt County Airport,725945
2	Sonoma County,CA,USA,Charles M. Schulz Sonoma County Airport,724957
3	Oakland,CA,USA,San Francisco Bay Oakland International Airport,724930
4	Paso Robles,CA,USA,Paso Robles Municipal Airport,723965
5	Santa Maria,CA,USA,Santa Maria Airport,723940
6	Los Angeles,CA,USA,Los Angeles International Airport,722950
7	San Diego,CA,USA,San Diego International Airport,722900
8	Fullerton,CA,USA,Fullerton Municipal Airport,722976
9	Burbank,CA,USA,Hollywood Burbank Airport,722880
10	Riverside,CA,USA,Riverside Municipal Airport,722869
11	Red Bluff,CA,USA,Red Bluff Airport,725910
12	Sacramento,CA,USA,Sacramento Executive Airport,724830
13	Fresno,CA,USA,Fresno Yosemite International Airport,723890
14	Palmdale,CA,USA,Palmdale Regional Airport,723820
15	Palm Springs,CA,USA,Palm Springs International Airport,722868
16	Blue Canyon,CA,USA,Blue Canyon Nyack Airport,725845

COMMENTS 1,Created for California Building Energy Code Compliance Software; Typical months selected from historical weather data to match long-term bias-corrected CDF generated using Cal-Adapt data; Created by Big Ladder Software on August 20 2024

COMMENTS 2,Future Dataset: LOCA2; Scenario: SSP3-7.0; Model: Combined; Historical Year Range: 2000-2020; Future Year Range: 2030-2059; Population-Weighted: True; Variable Weights: Global Horizontal Radiation Total (50%) -

[13] Weather Bureau Army Navy station identifier number

Dry Bulb Temp Avg (10%) - Dry Bulb Temp Max (5%) - Dry Bulb Temp Min (5%) - Dew Point Temp Avg (20%) - Wind Speed Avg (10%)