Climate Classification for Building Energy Codes and Standards: Part 2—Zone Definitions, Maps, and Comparisons

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ABSTRACT

This paper describes a new climate classification for use in characterizing the performance of energy efficiency measures for buildings. The classification is designed for use in energy codes and standards, design guidelines, and building energy analyses. This is the second paper in a two-paper series. The first paper contains background on climate classification and describes the development process for the new classification. This second paper presents the zone definitions both descriptively and mathematically, describes related climatic materials that have been developed, such as maps, and provides a comparison of the new classification with existing classifications. Significant advantages of the new classification are highlighted.

INTRODUCTION

This is the second paper in a two-paper series. The first paper contains background on climate classification and describes the development process for a new classification of climate intended for use in building energy codes and standards. This second paper presents the climate zone definitions both descriptively and mathematically, describes related climate materials that have been developed to support use of the classification, such as representative cities and maps, and provides a comparison of the new classification with existing classifications.

Climate has a major impact on the energy use of most commercial and residential buildings. Current energy codes and standards contain numerous requirements based on climate; for example, minimum R-values for roof insulation and maximum solar heat gain coefficients (SHGCs) for window glazing. Currently, ASHRAE's residential and nonresidential energy standards and the residential and commercial sections of the International Energy Conservation Code (IECC) use four different methods for specifying climate-dependent requirements (ASHRAE 1993, ASHRAE 2001, ICC 1999). In many situations, the climate data needed to determine which requirements apply are not included in the standard or code documents. Only the IECC's commercial section is fully self-contained with respect to climatic data. It is also the only one of the four that provides clear and unambiguous specification of which requirements apply anywhere in the United States. To use the others, a user must locate referenced documents and then exercise judgment in selecting the most appropriate location for climatic data for the project. In addition to creating usability problems, the lack of a consistent and effective approach for handling climate impedes the incorporation of ASHRAE-developed criteria into the nation's model building codes.

A new climate classification has been developed to help improve the implementation of building energy codes and standards in the United States. This classification may also prove useful in design guidelines, analyses of current or future building populations, and other programs or research dealing with the relationship between climate and building energy use. This new classification builds on widely accepted classifications of world climates that have been applied in a variety of different disciplines. It was developed using SI units and climate indices believed to be widely available internationally to facilitate the development of information on building energy efficiency that can be applied anywhere in the world.

Part 1 of this two-part series of papers reviews the evolution of general-purpose climate classifications as well as approaches used with current building energy codes and stan-

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dards. It then explains the process used to develop this new classification. In this paper, the climate zone definitions that make up the classification are presented and illustrated graphically. The new classification is also compared with those currently in use in a model energy code and an ASHRAE standard.

CLIMATE MATERIALS

The climate classification is the centerpiece of a set of climate materials developed for implementing energy codes and standards. The classification has taken several different forms in the climate materials—state and national maps, tables that list the climate zones for each state/county, and a table that defines the underlying climate criteria on which the zones are based. Maps have proven useful over the years as an effective way to enable code users to determine climate-dependant requirements. Zone numbers found on the maps serve as the index to a table of code requirements. The climate criteria, on the other hand, provide an explanation of the underlying basis for the maps and enable the classification to be applied outside of the United States. Climate zones defined rigidly from climate criteria inevitably contain discontinuities and awkwardly placed zone boundaries that align poorly with administrative jurisdictions; therefore, it was necessary to "smooth" some of the map boundaries. For code purposes in the United States, the maps and equivalent county-based lists must take precedence. The maps are clear and explicit and were developed to overcome ambiguities associated with classifications based directly on climate criteria.

Climate Zone Definitions

Tables 1A and 1B contain definitions and explanatory information for each of the 17 climate zones in the new classification.

TABLE 1A
Climate Zone Definitions for New Classification (Part A)

<table>
<tr><td colspan="2">A. Major Climate Type Definitions[1]</td></tr>
<tr><td colspan="2">I. Marine (C) Definition—Locations meeting the following criteria:
• mean temperature of coldest month between –3°C (27°F) and 18°C (65°F)[2] AND
• warmest month mean < 22°C (72°F)[3] AND
• at least four months with mean temperatures over 10°C (50°F)[4] AND
• dry season in summer.[5] The dry season in summer criterion is met when the month with the heaviest rainfall in the colder season has at least three times as much precipitation as the month in the warmer season with the least precipitation. The colder season is October, November, December, January, February, and March in the Northern Hemisphere and April, May, June, July, August, and September in the Southern Hemisphere. All other months are considered the warmer season, in their respective hemispheres.</td></tr>
<tr><td>II. Dry (B) Definition (SI)—Locations meeting the following criteria:
Not marine and
$P_{cm} < 2.0 \times (T_C + 7)$
where:
P_{cm} = annual precipitation in cm
T_C = annual mean temperature in degrees Celsius</td><td>II. Dry (B) Definition (I-P)—Locations meeting the following criteria:
Not marine and
$P_{in} < 0.44 \times (T_F - 19.5)$
where:
P_{in} = annual precipitation in inches
T_F = annual mean temperature in degrees Fahrenheit</td></tr>
<tr><td>III. Humid (A) Definition (SI)—Locations meeting the following criteria:
Not marine and
$P_{cm} \geq 2.0 \times (T_C + 7)$</td><td>III. Humid (A) Definition (I-P)—Locations meeting the following criteria:
Not marine and
$P_{in} \geq 0.44 \times (T_F - 19.5)$</td></tr>
</table>

Notes:
1. Humid, dry, and marine zone definitions are based on Strahler (1969), Plate 2, except as noted.
2. These criteria are necessary to exclude Köppen's (D) "snow" climates and (A) "tropical" climates.
3. This criterion excludes the (a) "hot in summer" climates, such as the southeastern and midwestern United States.
4. This criterion excludes some marine climates in high latitude locations, such as Alaska, Iceland, and northern Norway, from special treatment as marine climates.
5. This "dry season in summer" definition is from Köppen (1931) [German text, p.129]. The authors were unable to find in this text quantitative definitions for "colder season" and "warmer season," only an acknowledgement of the inherent difficulty in defining these seasons in a way that is effective for all world climates. The month-based definitions were created by the authors to make the climate definitions complete and computable.

Under the variants of the Köppen system reviewed for this work, the dry in summer criterion was part of the Cs (Mediterranean) but not the Cb (Marine, Cool Summer) subdivision. We included it in the general Marine zone definition for use in the United States because dry summers are a characteristic attribute of the Pacific marine climates that we felt were necessary to recognize in the classification. It was also useful in excluding isolated locations in other parts of the country from meeting the Marine zone criteria. Specifically, sites at higher elevations in the southern Appalachian Mountains (such as Asheville, NC) and medium elevations in the southwestern United States (such as Albuquerque, NM) otherwise marginally met the marine criteria. Outside of the United States, such as in Northern Europe where marine influences extend far inland and summers are not as dry, this criterion may not be useful and could be dropped.

TABLE 1B
Climate Zone Definitions for New Classification (Part B)

B. Thermal Zone Definitions					
Zone No.	**Climate Zone Name and Type[2]**	**Thermal Criteria[1, 3, 8]**	**Representative U.S. City[4]**	**Köppen Class.[5]**	**Köppen Classification Description[6]**
1A	Very Hot – Humid	5000 < CDD10°C	Miami, FL	Aw	Tropical Wet-and-Dry
1B[7]	Very Hot – Dry	5000 < CDD10°C	---	BWh	Tropical Desert
2A	Hot – Humid	3500 < CDD10°C _ 5000	Houston, TX	Caf	Humid Subtropical (Warm Summer)
2B	Hot – Dry	3500 < CDD10°C _ 5000	Phoenix, AZ	BWh	Arid Subtropical
3A	Warm – Humid	2500 < CDD10°C _ 3500 AND HDD18°C _ 3000	Memphis, TN	Caf	Humid Subtropical (Warm Summer)
3B	Warm – Dry	2500 < CDD10°C _ 3500 AND HDD18°C _ 3000	El Paso, TX	BSk/BWh/H	Semiarid Middle Latitude/Arid Subtropical/Highlands
3C	Warm – Marine	HDD18°C _ 2000	San Francisco, CA	Cs	Dry Summer Subtropical (Mediterranean)
4A	Mixed – Humid	CDD10°C _ 2500 AND HDD18°C _ 3000	Baltimore, MD	Caf/Daf	Humid Subtropical/Humid Continental (Warm Summer)
4B	Mixed – Dry	CDD10°C _ 2500 AND HDD18°C _ 3000	Albuquerque, NM	BSk/BWh/H	Semiarid Middle Latitude/Arid Subtropical/Highlands
4C	Mixed – Marine	2000 < HDD18°C _ 3000	Salem, OR	Cb	Marine (Cool Summer)
5A	Cool – Humid	3000 < HDD18°C _ 4000	Chicago, IL	Daf	Humid Continental (Warm Summer)
5B	Cool – Dry	3000 < HDD18°C _ 4000	Boise, ID	BSk/H	Semiarid Middle Latitude/Highlands
5C[7]	Cool – Marine	3000 < HDD18°C _ 4000	---	Cfb	Marine (Cool Summer)
6A	Cold – Humid	4000 < HDD18°C _ 5000	Burlington, VT	Daf/Dbf	Humid Continental (Warm Summer/ Cool Summer)
6B	Cold – Dry	4000 < HDD18°C _ 5000	Helena, MT	BSk/H	Semiarid Middle Latitude/Highlands
7	Very Cold	5000 < HDD18°C _ 7000	Duluth, MN	Dbf	Humid Continental (Cool Summer)
8	Subarctic	7000 < HDD18°C	Fairbanks, AK	Dcf	Subarctic

Notes:

1. Column 1 contains alphanumeric designations for each zone. These designations are intended for use when the zones are referenced in the code. The numeric part of the designation relates to the thermal properties of the zone. The letter part indicates the major climatic group to which the zone belongs; A indicates humid, B indicates dry, and C indicates marine. The climatic group designation was dropped for Zones 7 and 8 because we did not anticipate any building design criteria sensitive to the humid/dry/marine distinction in very cold climates. Zones 1B and 5C have been defined but are not used for the United States. Zone 6C (Marine and HDD18°C > 4000 (HDD65°F > 7200) might appear to be necessary for consistency. However, very few locations in the world are both as mild as is required by the Marine zone definition and as cold as necessary to accumulate that many heating degree-days. In addition, such sites do not appear climatically very different from sites in Zone 6A, which is where they are assigned in the absence of a Zone 6C.
2. Column 2 contains a descriptive name for each climate zone and the major climate type from Table 1A. The names can be used in place of the alphanumeric designations wherever a more descriptive designation is appropriate.
3. Column 3 contains definitions for the zone divisions based on degree-day cooling and/or heating criteria. The humid/dry/marine divisions must be determined first before these criteria are applied. The definitions in Table 1A and 1B contain logic capable of assigning a zone designation to any location with the necessary climatic data anywhere in the world. However, the work to develop this classification focused on the 50 United States. Application of the classification to locations outside of the United States is untested.
4. Column 4 contains the name of a SAMSON station found to best represent the climate zone as a whole (NCDC 1993). See discussion of the process used to select representative cities.
5. Column 5 lists abbreviations for the climate groups based on a simplified version of the Köppen system (Finch et al. 1957) that best match each zone. This information relates the climate zones to a widely used world classification system and may facilitate application outside the United States.
6. Column 6 contains a verbal description derived from Köppen's work that serves to explain the two- and three-letter codes in the previous column.
7. Zones 1B and 5C do not occur in the United States, and no representative cities were selected for these zones due to data limitations. Climates meeting the listed criteria do exist in such locations as Saudi Arabia, British Columbia, Canada, and Northern Europe.
8. SI to I-P Conversions:

2500 CDD10°C = 4500 CDD50°F	3000 HDD18°C = 5400 HDD65°F
3500 CDD10°C = 6300 CDD50°F	4000 HDD18°C = 7200 HDD65°F
5000 CDD10°C = 9000 CDD50°F	5000 HDD18°C = 9000 HDD65°F
2000 HDD18°C = 3600 HDD65°F	7000 HDD18°C = 12600 HDD65°F

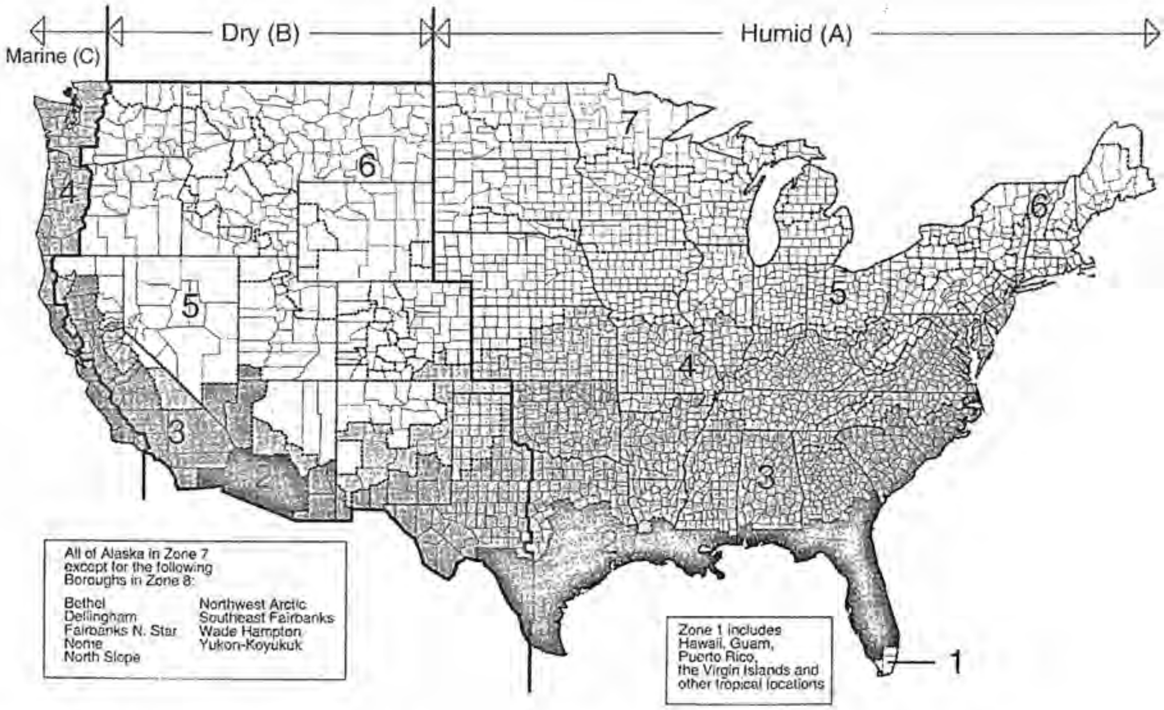

Figure 1 *Map of the United States showing climate zone assignments under the new classification.*

Climate Maps and Tables

Figure 1 presents the climate classification in the form of a map of the United States. The humid/dry/marine letter designations have been shown at the top of the map rather than with each zone number because some code requirements may use only the numeric (thermal) part of the zone designations. Larger scale maps showing only single states may be developed to facilitate code implementation in states containing more than one climate zone.

The climate materials include an alternate text-based presentation format. Several states, such as Texas and Georgia, contain a large number of relatively small counties. A table listing states and county zone assignments has been created to allow users to positively identify climate zone assignments in those few locations for which map interpretation may be difficult. The table was developed for inclusion in the body of a code or as a normative appendix.

Representative Cities

This section and the next section discuss the development of two additional sets of data that complement the climate classification—representative cities and a mapping of counties to SAMSON weather stations (NCDC 1993). This information is pertinent to energy code development and to performance-based code compliance, respectively. Similar methods were used in developing each of these sets of supporting data.

We selected a representative city for each of the climate zones that occur in the United States (see Table 1B) to facilitate use of the classification in code development and other types of analyses. For example, code criteria could be developed for a given climate zone based on simulation performed using the designated representative city for that climate zone. Cities were selected from among the SAMSON stations for which TMY2 hourly weather files are available (Marion and Urban 1985). (We hereafter refer to these as SAMSON stations.) The representative city assignments are not intended for code users (i.e., those required to demonstrate compliance with the code) and are not intended for inclusion in the code document itself.

In choosing representative cities we sought to satisfy two criteria. First, it is desirable that the representative city be similar to the "average" weather conditions within a zone, not favoring either mild or harsh climates and preferably located somewhat centrally within the zone's geographic extent. Second, a representative city should, to the extent possible, favor weather conditions where buildings are predominantly located. These criteria are often in conflict since population centers tend to be in the milder climates. Because the potential uses of the representative cities are many and varied, there is no one "correct" set. The set we have chosen represents a compromise that facilitates a reasonable intuitive understanding of the climate zones and can be used to make reasonable assessments of energy performance of buildings within the climate zone. For situations that require better isolation of local climatic nuances, we have also mapped each individual county to a SAMSON station, as discussed briefly in the section titled "Mapping Counties to SAMSON Stations."

Our approach for selecting representative cities was to examine the distribution of towns and cities within each climate zone and, using information about the cities' weather (heating and cooling degree-days) and population, identify a "best" SAMSON station to represent the cities in the zone. We made use of two supplementary databases of climatic data and city information. First is a NOAA database of 4775 cities for which aggregate climatic information is available (Owenby et al. 1992). The NOAA database has been used for prior code-development work and is the basis for much of the climatic information available in the MEC*check* and COM*check* code compliance software (DOE 1995, 1997). Each NOAA location was mapped to a SAMSON station that best matches its climate, as discussed below.

The second database was used to get better geographical coverage than is possible with the 4775 NOAA locations. The Populated Places database (PPL) is part of the Geographic Names Information System of the U.S. Geological Survey (USGS 2000). The PPL data include latitude, longitude, elevation, and population for over 164,000 identifiable locations (or "features" as they are called in the PPL documentation) in the U.S. and its territories. The PPL features are mostly cities and towns but also include large housing subdivisions and other unincorporated places. While this level of geographical coverage is perhaps overkill for selecting zone-level representative weather stations, it is very helpful for county level mappings (see "Mapping Counties to SAMSON Stations"). Also, because the PPL locations are tied directly to population, they better represent the geographic distribution of buildings than do the NOAA locations, many of which represent climates not typical of building construction, such as mountain tops, dams, forest lookout stations, etc.

The PPL data provide very good geographical coverage of the United States. However, since there is no climatic information included in PPL data, it was necessary to map each PPL location to one of the 4775 NOAA locations, as described below. Each NOAA location was further mapped to a best representative SAMSON station, enabling each PPL location to be mapped to a representative SAMSON station. This allowed us to quantify the number, distribution, and population of cities and towns in each climate zone that are mapped to each SAMSON station. We used a combination of the total population referencing each SAMSON station and population-weighted climate means (e.g., HDD65°F [HDD18°C] and CDD65°F [CDD18°C]) to inform our selection of SAMSON stations to represent each zone. The final selections were based on subjective evaluations of these criteria, an effort to provide good representation for all U.S. regions in the representative city set as a whole, and a deliberate bias toward the more populous and better known stations. The results are shown in Table 1B.

Mapping NOAA Locations to SAMSON Stations. In most cases, the best SAMSON station is the one closest to the subject NOAA location—the 4775 NOAA locations give fairly good coverage of much of the country. However, in many mountainous regions or sparsely populated regions the closest SAMSON station is not necessarily the best choice. We defined a new distance metric that incorporates not only the actual number of miles between NOAA/SAMSON pairs but also the differences in heating and cooling degree-days and elevation.

We expressed the new distance metric in units of miles to facilitate reasoning about the differences. To transform degree-day and elevation differences into units of miles, we calculated an equivalent latitude miles. This quantity is based on the observation that as one moves northward (increasing latitude) or upward (increasing elevation), heating degree-days tend to increase and cooling degree-days tend to decrease. A regression analysis of the degree-day and elevation differences between various NOAA/SAMSON pairs allowed us to conveniently quantify those differences in units of miles. The equation resulting from that analysis is

$$d_{equiv} = I + \alpha \times \Delta HDD + \beta \times \Delta CDD + \gamma \times \Delta Elev$$

where

d_{equiv}	=	equivalent latitude distance between locations (miles),
ΔHDD	=	difference in heating degree-days between locations (base-65°F),
ΔCDD	=	difference in cooling degree-days between locations (base-65°F),
$\Delta Elev$	=	difference in elevation between locations (feet),
I	=	–6.88315367,
α	=	0.10607746,
β	=	–0.01485033,
γ	=	–0.07184735.

The best SAMSON station for each NOAA location was selected as the one with the minimum total distance:

$$d_{total} = d_{actual} + d_{equiv}$$

where

d_{actual}	=	actual distance between locations (miles),
d_{equiv}	=	equivalent latitude distance between locations (miles),
d_{total}	=	total distance describing geographical and climatic difference between locations (miles).

Mapping PPL Locations to NOAA Locations. Because of the vast number of PPL locations available (158,408 in the 50 states) it is almost always possible to select the nearest NOAA location as the best representation of the local climate. The exceptions are when the PPL location and the nearest NOAA location have very different elevations. Our process for assigning a representative NOAA location to each PPL location was quite simple:

1. For each PPL location, identify the 20 nearest NOAA locations based on geographic distance.
2. If the elevation of the nearest NOAA location is within 300 feet of that of the PPL location, use that NOAA location.
3. Otherwise, choose from among the 20 nearest NOAA locations the one that is nearest in elevation to that of the PPL location.

Mapping Counties to SAMSON Stations

Virtually every building energy code that has been developed for use in the United States has included a performance-based compliance path, which allows users to perform an energy analysis and demonstrate compliance based on equivalence with prescriptive requirements. In 90.1-2001, the method is called the, "Energy Cost Budget Method" (section 11), and in the IECC it is called, "Systems Analysis" for residential buildings (in Chapter 4) and "Total Building Performance" for commercial buildings (in Section 806).

To perform these analyses, users must select appropriate weather data given their project's location. Ordinarily these analyses require the use of 8,760 hours of weather data representing a typical weather year—data that are available for the SAMSON stations but not for any of the other data sets. The selection of appropriate weather data is entirely straightforward for any project located in or around one of the 237 SAMSON stations available for the United States and possessions. For other locations, selecting the most appropriate site can be problematic. Current energy codes offer little help in these selections; they usually require the user to use climate data from a site that is "appropriate," "representative," "closest," or "approved." To simplify these decisions for users, we mapped every county in the United States to the most appropriate SAMSON station for each county as a whole. This mapping is not necessarily intended for inclusion in the code but could be included as an informative appendix to the code, included in a supporting document such as a user's guide, or embedded in compliance software.

This mapping can be used in the absence of better information but should not necessarily be considered the only climatic data permitted for a given county. Code officials and design practitioners may have access to data that better reflect regional or even microclimatic conditions than those available nationally for this work. Elevation has a large impact on climate, and elevation can vary dramatically within individual counties, particularly in the western United States. Where elevation differences are significant, code officials may require use of sites that differ from these designations for performance-based compliance.

Appropriate treatment of elevation differences remains an unresolved issue in current energy codes. The new climate classification does not attempt to resolve this issue, leaving the problem in the hands of state and local code authorities. Where very high (or unusually low) elevation sites exist within a jurisdiction, code authorities may require use of SAMSON stations for performance-based compliance that differs from the locations indicated in this mapping.

The method used to assign counties to SAMSON stations was very similar to the method used to assign representative cities to the climate zones (see "Representative Cities"). The main difference is that far less subjective evaluation was needed, and county assignments were based almost entirely on the total population of PPL locations mapped to each SAMSON station. That is, for each county, the representative SAMSON station is that station to which the greatest total PPL population "points."

COMPARISONS OF NEW AND EXISTING CLIMATE ZONES

An objective for any effective classification is to maximize between-group variation over the parameters of interest while minimizing within-group variation. A large between-group variation will enable generalizations embodied in the code requirements to be better tailored to each climate zone. A small within-group variation will ensure that the generalizations will fit each zone. We contend that this new classification better represents climatic diversity while defining more coherent climate zones than the classifications it is designed to replace.

The following sections present brief comparisons between the new classification and the current IECC maps and the 90.1-2001 climate bins. However, given the many similarities between the new classification and the maps currently in the IECC, rigorous analysis of the differences hardly seemed warranted. Instead, a brief discussion is provided that highlights major differences.

Comparison with Existing IECC Zones

The climate zones under the new classification represent a significant but evolutionary change from those in the 1998 through 2002 editions of the IECC. There are two chief differences between the classifications: 1) most dividing lines are based on 1800 degree-day Fahrenheit (1000 degree-day Celsius) divisions rather than 500 degree-day Fahrenheit (278 degree-day Celsius) increments, and 2) the A, B, and C climate zone subdivisions used to reflect other climatic dimensions have been redefined to align with major, widely recognized climatic types.

The increase in the size of degree-day bands has reduced the number of climate zones but also the coherence of the resulting zones, at least with respect to the degree-day parameters. Most interested parties seem willing to accept the reduced coherence in exchange for the significant (roughly 50%) reduction in the number of zones. However, offsetting the reduction in coherence due to larger degree-day bands is the fact that many of the new divisions simply make more sense climatically than those they are designed to replace. The new A, B, and C divisions have been used judiciously to better

Figure 2a *Distribution of locations belonging to 90.1-2001 bins.*

Figure 2b *Distribution of locations belonging to climate zones under new classification.*

address climatic differences that have long been recognized as significant, which is not the case for the A, B, and C divisions in the current IECC maps. Other refinements, such as the use of cooling criteria as the basis for zone divisions in cooling-dominated climates, also serve to offset some of the "imprecision" introduced by using wider temperature bands.

Comparison with 90.1-2001 Climate Bins

Roughly 5,000 climate sites and their associated climate zone (or bin) assignments are shown overlaid on a map of the United States in Figures 2a and 2b. Figure 2a shows the bin assignments based on 90.1-2001, and Figure 2b shows the bin assignments based on the proposed classification. In Figure 2a, bins 1 through 9 are designated by their zone numbers, while bins 10 through 23 are designated by letters; i.e., Zone 10 by "a," Zone 11 by "b," and so on. In Figure 2b, the "A" (humid) zones and Zone 7 are designated using their numbers 1 through 7, "B" (dry) zones are designated using the letters a through f, and "C" (marine) zones are designated using the letters g and h. Both figures are based on strict bin or zone definitions; therefore, Figure 2b provides a picture of where divisions naturally fell prior to adjustments to better align them with state and county boundaries.

There are many similarities between the two figures. The zone assignments in Figure 2a appear a bit more variable partly because of the larger number of the categories displayed—23 vs. 14 in 2b. However, additional attributes of the distribution in 2a make coherent and effective geographic boundaries difficult to define. There is more overlap and interpenetration of the zone designations in Figure 2a than 2b. Further, where interpenetrations occur, there are often three or more bins interspersed. Any map developed to represent these categories must either be very complex or require extensive manual intervention to simplify. Figure 2b also shows some overlap of zone numbers, but these overlaps usually involve only two adjacent zones, affecting only the appearance of the dividing line between them.

Other problematic attributes of the Figure 2a distribution are that quite dissimilar climate types share the same bin designations. For example, Bin 5 includes sites in both the arid Southwest and the humid Gulf Coast and Florida. This climatic variation results in very large within-group variations for all parameters related to moisture. Sites in Bin 14 can be found in a band from Puget Sound in the Pacific Northwest to Northern California and also in the Philadelphia and New York metropolitan areas. Bin 14 sites can also be found in Southern California, Arizona, Tennessee, and North Carolina. Several other bins, such as Bin 17, map to an even broader geographic area. Bin 17 can be found in no less than 30 different states. In contrast, under the new classification with 32% fewer zones, no climate zone can be found in more than 17 states.

Obviously, Figures 2a and 2b do not provide a definitive view of the effectiveness of these classifications. A rigorous statistical analysis probably could establish useful metrics for measuring the relative performance of the two classifications, although performing such analyses was not within the scope of this effort. However, the comparison they do offer is at least suggestive of some of the advantages offered by this new climate classification.

CONCLUSION

This paper has presented a new climate classification for use in implementing building energy codes, standards, and beyond-code guidelines. We believe the new classification will prove simpler, more effective, and easier to use than those currently in use. Evidence presented in this paper and the companion paper, "Climate Classification for Building Energy Codes and Standards: Part 1 – Development Process," support the following assertions (Briggs et al. 2003):

- A need exists for improved methods and materials for addressing climate in current energy codes and standards.
- The classification presented here is substantially simpler and more concise than current materials. The package of materials (maps, tables, zone definitions, and data files) developed to support the classification offer the potential to make codes and standards that use the materials less complex and easier to use.
- The new classification is well rooted in scientific approaches to climate classification. Its use of SI units and basis on a classification system that enjoys global acceptance may encourage acceptance of codes and standards that utilize the new classification outside of the United States.
- While this paper does not attempt to provide analytical proof, the comparisons with current approaches presented in this paper suggest the new classification offers an improved treatment of climate—offering climate zones that both are more homogeneous and better represent the range of climates found in the United States.

It is not possible to develop a classification for something as complex and multidimensional as climate that will be ideal for all applications and all situations. The new classification is intended to strike an appropriate balance between simplicity and usability on the one hand and accuracy and analytical power on the other. If both the ASHRAE standard development community and the building code community find that an effective balance has been achieved, this work could help expedite the incorporation of improved technical materials into the nation's building codes.

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