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COMPARISON OF TMY AND TRY DATA

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A COMPARATIVE STUDY OF THE TRY AND TMY METEOROLOGICAL DATA

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ABSTRACT

This study compares the data for 20 sites common to the Test Reference Year (TRY) and Typical Meteorological Year (TMY) data sets. The TRY and TMY data was compared in terms of eight statistics that are important in determining heating and cooling loads in buildings and solar systems performance. The eight statistics include average dry-bulb and dew-point temperatures, heating and cooling degree-days, humidity ratio, and average insolation values. For most locations the average dry-bulb temperatures agreed fairly well. The heating and cooling degree-day values also were close, with standard deviations less than 10% of typical values. However, the statistics relating to ambient humidity did not agree, and the insolation values generated from the TRY data (with the ASHRAE/DOE-2 algorithm) were quite different from the TMY values. Overall, the TRY and TMY data sets are not interchangeable over a wide range of simulation problems.

INTRODUCTION

An initial stumbling block in solar system and building performance design has been the lack of widely accepted "representative" weather data. At present, two major sets of typical data dominate: the TRY, established by a technical committee of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE); and the TMY, which was chosen by Sandia Laboratories under contract to the Department of Energy (DOE).

To understand the differences between the TRY and TMY data sets, one must understand how each of the data sets was chosen. The TRYs were chosen on the basis of dry-bulb temperature alone [1]. Years that contained temperature extremes were eliminated from the collection of years for which data were available. Thus, the first year eliminated was that which contained the hottest July; the second year eliminated was that containing the coldest January, etc. After all but one of the available years of data had been eliminated, the remaining year was designated the Test Reference Year.

By contrast, the data for TMYs were chosen on a monthly basis [2]. Thus, a TMY is normally composed of one month from each of 12 different years. The pool of available data was narrowed to five candidate months based on a statistic that included the weighted effects of dry-bulb temperature, dew-point temperature, wind velocity, and insolation. Table 1 shows the weighting factors used. The single most typical month was chosen from among the five candidate months on the basis of the day-to-day "persistence" of the dry-bulb temperature and global radiation. The procedure that was used to select the TMY data thus gives primary consideration to insolation values and much less consideration to other factors such as dry-bulb temperature.

Table 1. Weighting Factors Used in Selecting Candidate Months for TMYs[a]

Dry Bulb			Dew Point		
Min	Mean	Max	Min	Mean	Max
1/24	2/24	1/24	1/24	2/24	1/24
Wind Velocity			**Solar Radiation**		
Max	Mean				
2/24	2/24		12/24		

[a]From Ref. [2].

Of course, the user's main concern with these procedures is whether they produce a data set that is representative of the long-term data for a given location. This issue has been addressed by studying each of these data sets individually. Arens et al. [5] compared the number of heating and cooling degree-days calculated from the TRY data to those calculated from the long-term data. His results showed that although the TRY data contained slightly cooler temperatures than the long-term data, the agreement was good. Freeman [6] made an exhaustive examination of the representativeness of the TMY data in terms of both the building loads and predicted solar system performance. He discovered some discrepancies in the solar system performance predicted for months with low loads, and he doubted the typicality of the diffuse radiation. However, he concluded that the agreement between the TMY and the long-term data was adequate for most simulation work, especially when the desired results were seasonal or annual values.

In this study, the TMY and the TRY data are compared for agreement in terms of eight meteorological statistics chosen on the basis of their importance in determining both building loads and active and passive solar system performance. The statistics used are:

1. Average dry-bulb temperature
2. Heating degree-days, base temp. = 65°F (18.3°C)

3. Cooling degree-days, base temp. = 65°F (18.3°C)
4. Average dew-point temperature
5. Total hourly differences between the ambient humidity ratio and the humidity ratio at 77°F and 50% relative humidity (Δw)
6. Average daily direct radiation on a horizontal surface
7. Average daily diffuse radiation on a horizontal surface
8. Average daily global radiation on a horizontal surface

These statistics were compared on both a monthly and an annual basis for 20 sites common to TRY and TMY data. These sites are shown in Fig. 1. Since both of these data sets claim to reflect the long-term meteorological trends in at least some respects, this study examines how well they agree with each other. That is, to what degree are they interchangeable?

Fig. 1. Locations of the 20 sites Common to the TRY and TMY Data Sets.

RESULTS

Dry-Bulb Temperature

Although the TMY selection procedure weighted dry-bulb temperature rather weakly, the agreement between the two data sets in this area was reasonable. The standard deviation of the differences in the monthly averages was 1.3°C, while the standard deviation of the differences between the annual values was only 0.6°C. Figure 2 shows a scatter plot of annual averages from the TRY plotted against those from the TMY. Each point on the plot represents one of the 20 locations shown in Fig. 1. The worst agreement was found for Washington, D.C., which had a monthly standard deviation of 2.09°C.

Heating and Cooling Degree-Days

The number of heating or cooling degree-days for a given period is a function of both the average dry-bulb temperature for that period and the spread of the hourly temperatures around that average. The number of degree-days provides a single measure of the overall congruence of the

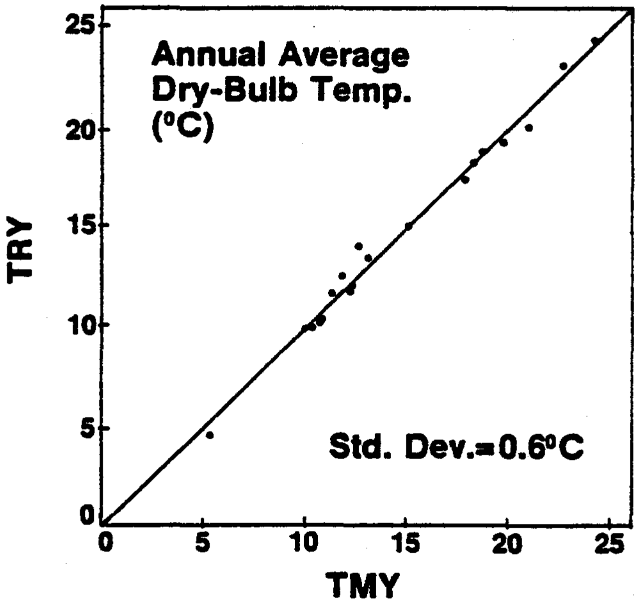

Fig. 2. TRY vs. TMY: Annual Average Dry-Bulb Temperatures (°C).

two sets of temperature data. In this study, both heating and cooling degree-days were based on a temperature of 65°F (18.3°C).

Figure 3 shows the annual heating degree-day values from the TRY data plotted against those from the TMY data. The standard deviation of the differences between the annual values was 142 degree-days, while the standard deviation for the monthly values was 40 degree-days. For a location with about 3000 heating degree-days annually or

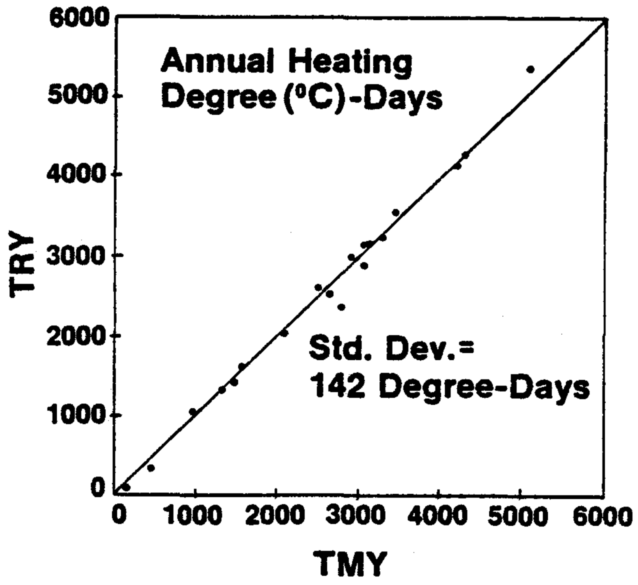

Fig. 3. TRY vs. TMY: Annual Total Heating Degree(C)-Days.

500 degree-days monthly (such as Columbia, Mo.), these values represent about 5% and 8% of the totals, respectively. TMY and TRY data agreed the least for Washington, D.C., where the TMY data predicted 16% more annual heating degree-days than the TRY data. Overall, the cooling degree-day data did not agree quite as well as the heating degree-day data. Figure 4 shows a scatter plot of annual cooling degree-days from the TRY data versus those from the TMY data. The standard deviation of the differences in the annual cooling degree-days was 80 degree-days, and the monthly standard deviation was 23 degree-days. For a location such as Nashville, Tenn., with ~1000 cooling degree-days annually and ~250 cooling degree-days monthly, these standard deviations represent about 8% and 10%, respectively, of these totals.

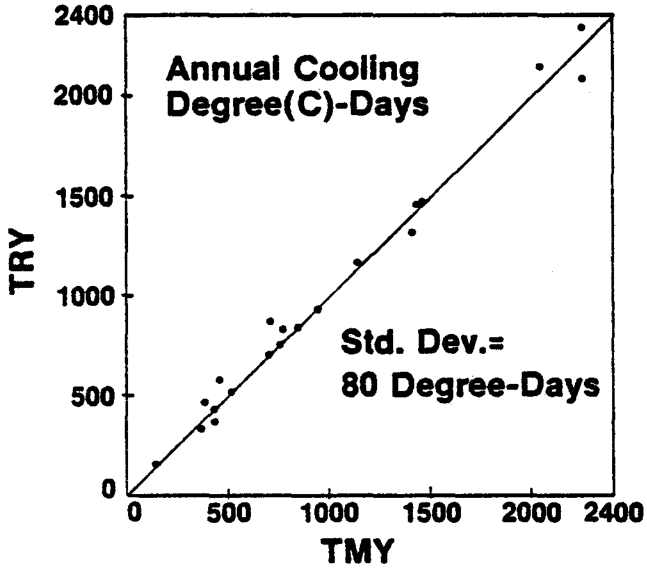

Fig. 4. TRY vs. TMY: Annual Total Cooling Degree(C)-Days.

Overall, these figures demonstrate reasonable agreement between TRY and TMY data sets for most locations. Because the method used to find the TMY offered much more month-to-month flexibility, this agreement is remarkable.

Dew-Point Temperature

Because the TRY selection process chose only on the basis of "nonextreme" dry-bulb temperatures, the typicality of meteorological factors indicative of latent cooling loads was ignored. On the other hand, the TMY selection process weighted typicality of the dew-point temperature equally with that of the dry-bulb temperature. Thus, any degree of agreement between TRY and TMY data sets in this area is fortuitous. Figure 5 shows a scatter plot of annual average dew-point temperatures. The standard deviation of the differences between the annual averages was 0.9°C, while the standard deviation of the monthly averages was 1.9°C. These values are about 50% larger than those for the dry-bulb temperature, indicating significantly worse agreement.

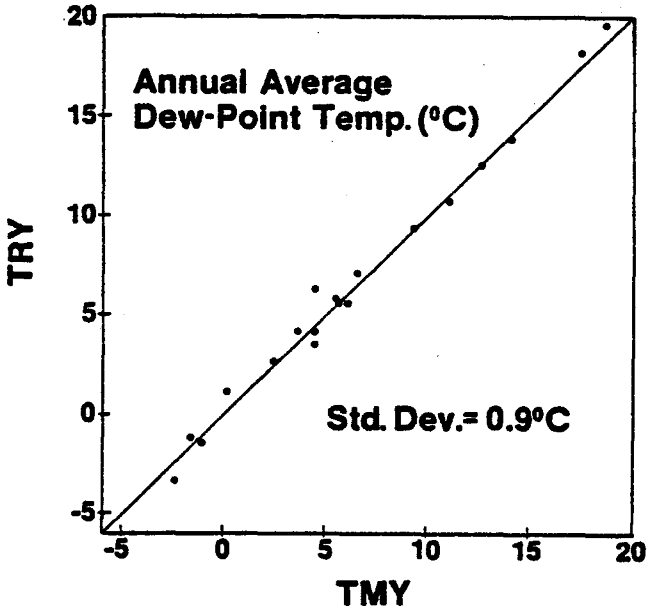

Fig. 5. TRY vs. TMY: Annual Average Dew-Point Temperature(C).

Humidity Ratio

Although the average dew-point temperature indicates the average humidity, there is no universally accepted figure that describes the spread of the individual humidity values about the average value in the way that degree-days do. To get some feeling for this spread, a quantity that represented the difference between the ambient humidity ratio (calculated from the dew-point temperature) and the humidity ratio at 77°F and 50% relative humidity ($w = 0.01$) was used. This humidity difference (Δw) thus represents the lb_m of water (per month or year) that would have to be removed from the air if the infiltration or ventilation rate were 1 lb_m of air per hour.

The annual totals for TRY data are plotted against those for TMY data in Fig. 6. The agreement between the data sets is poor for either large or small values, i.e., for either very humid or dry climates, and the TRY values tend to be higher than the TMY values. The annual and monthly standard deviations are 1.72 and 0.44 lb_m $H_2O/(lb_m$ air/hr), respectively. Although the annual totals reasonably agree, the monthly values do not agree well. Therefore, the two data sets will not predict the same latent cooling loads on a monthly basis, and on an annual basis, the TRY data tend to predict higher latent loads than TMY data. Since the TRY data was chosen without regard for typicality of dew-point temperatures, it seems reasonable to assume that the latent cooling loads predicted by the TMY data will be more representative of the long-term data.

Insolation

The TRY data do not contain solar insolation data. However, programs such as DOE-2 contain an ASHRAE algo-

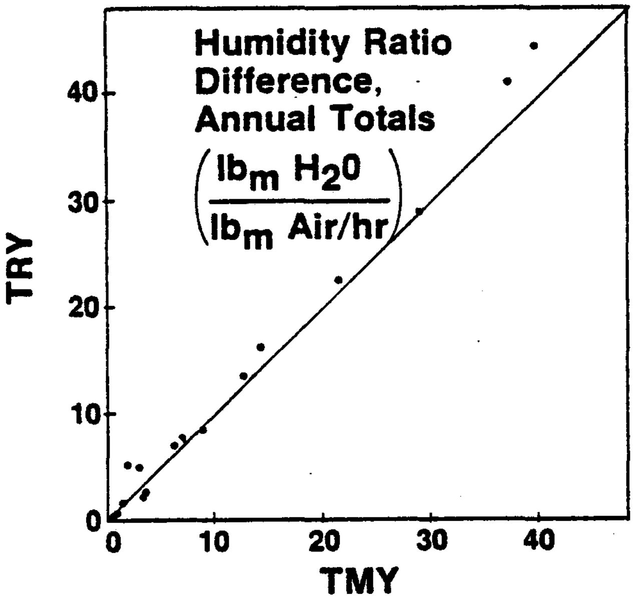

Fig. 6. TRY vs. TMY: Annual Total Hourly Difference Between the Ambient Humidity Ratio and the Humidity Ratio at 77°F and 50% Relative Humidity.

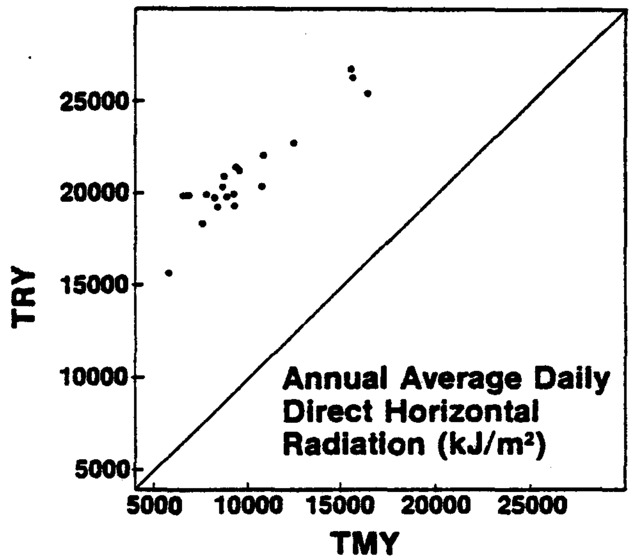

Fig. 7. ASHRAE Algorithm Using TRY Data vs. TMY: Annual Average Daily Direct Radiation on a Horizontal Surface.

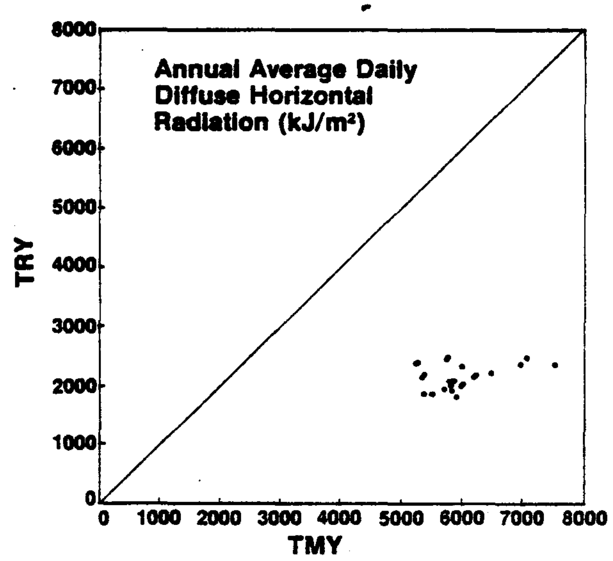

Fig. 8. ASHRAE Algorithm Using TRY Data vs. TMY: Annual Average Daily Diffuse Radiation.

rithm [3,4] that generates direct and diffuse insolation values from the cloud cover data available in the TRY data. The values of direct and diffuse horizontal radiation generated by this algorithm were used for this comparison.

The TMY data contain values for both global horizontal (standard year corrected) and direct normal radiation. To make direct comparisons between the TMY values and the values generated from the TRY data, several calculations had to be performed. First, the direct normal radiation had to be corrected to direct horizontal radiation. Then the diffuse horizontal could be obtained by subtracting the direct horizontal from the global horizontal. In this way, three monthly average daily radiation numbers were calculated for comparison: direct horizontal, diffuse horizontal, and global horizontal.

The results of this comparison showed major discrepancies between the insolation values calculated by DOE-2 from the TRY data and the values from the TMY data. Figures 7, 8, and 9 present the annual average daily direct, diffuse, and global radiation, respectively. The direct radiation values generated from the TRY data are consistently 1.5 to 2 times higher than the TMY values for all 20 locations. On the other hand, the diffuse radiation values generated from the TRY data are consistently only 1/3 to 1/2 as large as the TMY values. Since the global radiation is the sum of the direct and diffuse, any differences in these two values are reflected in the global radiation. However, since the direct radiation values are so much larger than the diffuse values, the differences in direct radiation dominate, and the TRY-generated global radiation values are much larger than the TMY values.

This comparison of TMY insolation data with an ASHRAE/DOE-2 algorithm is not a true comparison between TMY and TRY data. Unless the TMY data are grossly unrepresentative, the algorithm is deficient in generating reasonable values.

CONCLUSIONS

The TRY and TMY data sets agree marginally well on statistics related to dry-bulb temperature, giving standard deviations within 10% of typical values for both the

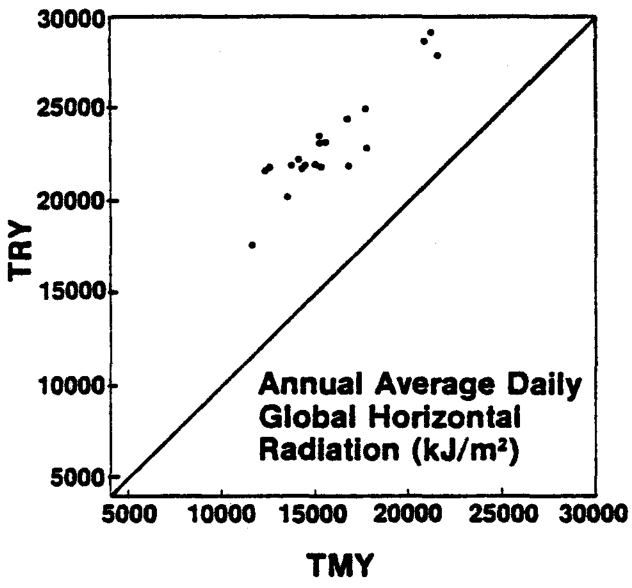

Fig. 9. ASHRAE Algorithm Using TRY Data vs. TMY: Annual Average Daily Global Radiation on a Horizontal Surface.

annual and monthly degree-day figures. However, the agreement of the statistics for humidity is not as good, and the insolation values do not agree.

To a user, the importance of these discrepancies depends upon the type of building or system that is to be simulated. For example, the heating loads predicted by the two data sets for a large commercial building whose load is dominated by internal generation and ventilation requirements should agree fairly well. The sensible cooling loads for such a building should be very similar. However, the two data sets will predict substantially different results if they are used to predict latent cooling loads, loads on skin-dominated buildings where solar gain is important, or other types of solar installations.

Of course, improvement of the ASHRAE/DOE-2 insolation generating algorithm would probably alleviate some of these problems, and if TRY data is to be used, this algorithm must be improved. However, it seems that one certainly cannot use TRY and TMY data interchangeably over a broad range of problems.

ACKNOWLEDGMENT

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