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Proposal of typical and design weather year for building energy simulation

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ABSTRACT

In building design or research processes, building energy simulations (BES) are conducted using weather data. There are two types of weather data for BES: typical weather year is used to estimate annual cooling/heating loads and design weather data to estimate maximum cooling/heating loads. In this study, we propose a new type of weather year data (called the Typical and Design Weather Year: TDWY) that can be used as both typical weather year and design weather data. To create the TDWY, we selected an average year based on Finkelstein-Schafer statistics and applied quantile mapping (QM) to the average year with parent multi-year (MY) weather data. The cumulative distribution functions of the TDWY created by QM consist completely of parent MY weather data for all the weather components used in QM. As the monthly and annual averages of the TDWY based on QM are equal to those of the parent MY weather data, high performance of the TDWY as typical weather year can be expected. In addition, the hourly values of the TDWY include from the minimum value to the maximum value of the parent MY weather data each month, so the TDWY can also be used as design weather data. To validate the performance of the TDWY, we conducted BES. The TDWY showed better than double the performance for estimating average cooling/heating loads compared to the existing typical weather year and could accurately estimate maximum cooling/heating loads.

1. Introduction

Weather data is necessary for creating building energy simulations (BES) and designing energy efficient buildings. There are two types of weather data for BES: typical weather year is used to estimate annual heat load, and design weather data to estimate maximum heat load. Each of these is made from multi-year (MY) weather data. In this study, we propose a method for making a new type of weather year data called the Typical and Design Weather Year (TDWY), using quantile mapping (QM), which could be used in the place of both current typical weather year and design weather data.

Existing methods for making a typical weather year for BES generally connect monthly segments of weather data selected from MY meteorological records using summary statistics, such as monthly averages or Finkelstein–Schafer (FS) statistics [1–3]. For example, the Test Reference Year (TRY) by the Chartered Institution of Building Services Engineers (CIBSE) and International Weather Years for Energy Calculations (IWECs) by ASHRAE are made by this conventional method, based on FS statistics. The earliest typical weather year, such as the Test Reference Year (TRY) in 1976 by ASHRAE and Example Weather Year (EWY) in 1978 by CIBSE, were made using single-real-year weather data selected from MY weather data in order to avoid discontinuities in the weather sequence throughout the whole year. However, it is rare to get an average year that sufficiently represents parent MY weather throughout the year. Therefore, the method of connecting the average monthly weather data to make a typical weather year has been predominately used in recent years. Although the typical weather year made by linking average monthly weather data is better than average entire year data for BES, the ability of the typical weather year to represent the parent MY weather data depends on the parent weather data, the selection method, and the length of the selection period [4].

Design weather data is made to represent the most severe weather conditions that have occurred during a number of years, and it is used to estimate the maximum heat load in BES. Different

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Table 1
Comparison of the characteristics of four types of weather data for building energy simulations.

Characteristics	TWY[a]	DWD[b]	MY[c]	TDWY[d]
Amount of weather data	One single year	Several days	Multiple years	One single year
Ability to represent the average weather conditions	Yes (depends on parent weather data, selection method and selection period)	No	Yes	Yes
Ability to represent severe weather conditions	Not well	Not enough	Yes	Yes
Amount of simulation	One round	One round	Multiple rounds	One round
Ease of the simulation process and data handling	Yes	No (Most software for BES requires year weather data)	No	Yes

[a] TWY: Typical Weather Year.
[b] DWD: Design Weather Data.
[c] MY: Multi Year Weather Data.
[d] TDWY: Typical and Design Weather Year.

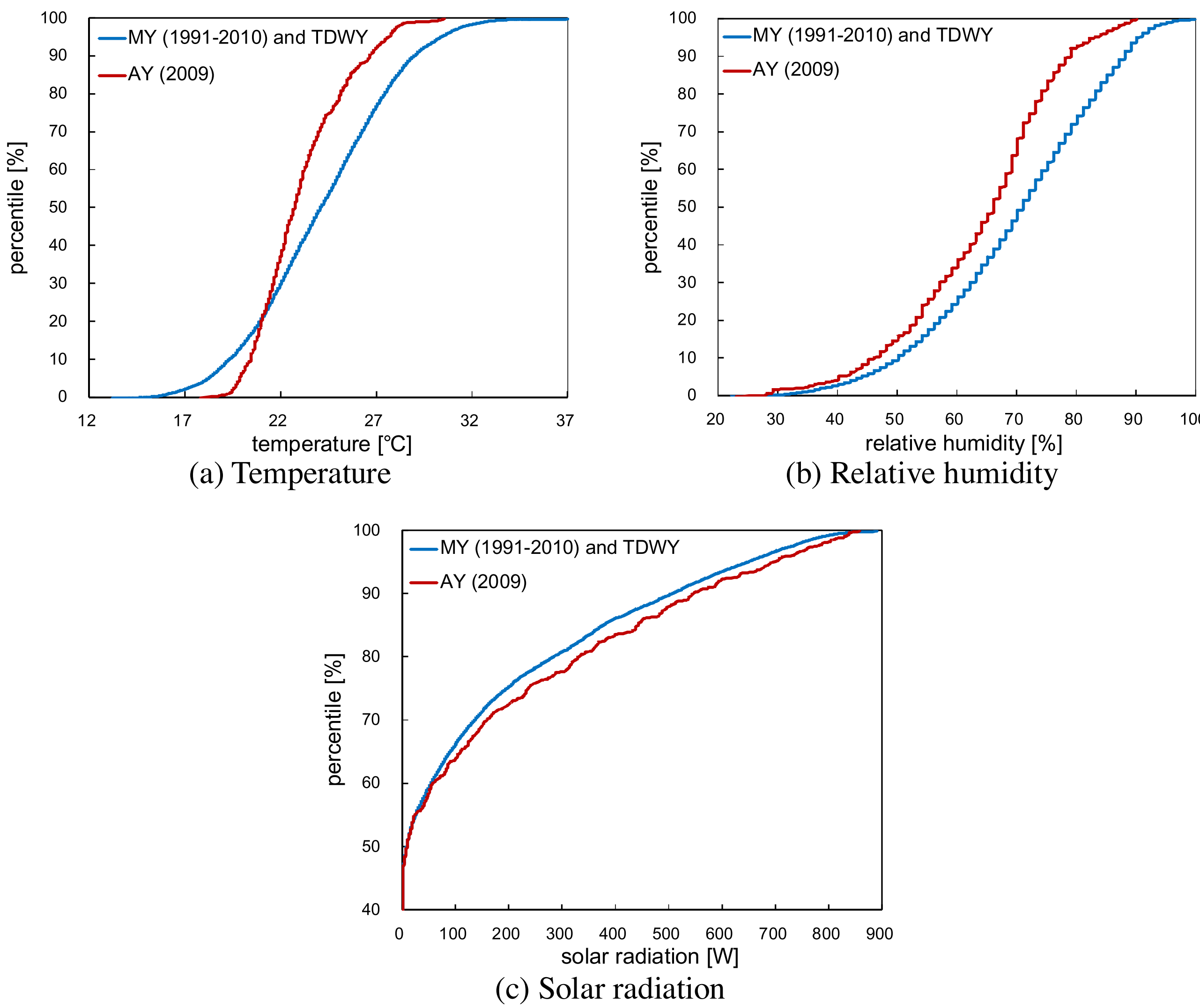

Fig. 1. Cumulative distribution functions (CDFs) for each weather component of average year (AY) and multi-year (1991–2010) weather data (MY), and the typical and design weather year (TDWY).

types of design weather data have been proposed; for example, Design Summer Years (DSYs) were developed by CIBSE as year weather data to estimate the maximum heat load in summer [5]. In creating the earliest DSY, the year that had the third highest period of average temperatures from March to September was selected. As the DSYs based on this simple method were not suitable to be used as design weather data, the method for DSYs has been continually improved to include severe climatic conditions more appropriately [6]. Colliver et al. presented a multi-day (1, 3, 5, 7 days) weather data as design weather data by selecting the consecutive multi-day weather data that have most severe multi-day average from MY weather data and using the data directly for consecutive multi-day BES [7]. However, it is difficult to select ideal design weather data from actual weather data because the maximum heat load is