Effects of Climate Change on China Building Climate Demarcation

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***Abstract*—The building climate demarcation standard currently being used is based on the weather data of 1951-1985, which was issued in 1993. China's weather has changed significantly with the changes of the global weather and the increase of urban heat island effect. Temperatures in most cities in China have changed much in comparison with the temperature during the years of 1951-1985 and 1986-2008. In order to see the effects of climate change on building climate demarcation, the same parameters and conditions as were previously used have been adopted to classify building climate zones within the recent 30 years of weather data of 1979-2008. The meteorological data used in this paper is from the American National Climate Data Center (NCDC), which is reported to NCDC by meteorological bureaus of different countries and are proved to be reliable. We found that the building climate demarcation boundaries have been moved quite remarkably, and some locations have moved from one zone to adjacent areas of neighboring zones. The regionalization boundary may have shifted with the largest displacement of 1°30′ in latitude. This change has been discovered in every zone, which covers the large or average sized cities. In this paper, we have addressed some suggestions for practical building climate demarcation.**

***Keywords-global climate change; climate demarcation; heat island effec*t**

I. INTRODUCTION

Building and climate are closely related. Climate may have a dramatic impact on architectural planning, design, and construction. Building design, construction specification and implementation of regional energy efficiency standards are all dependent upon the basis of the building climate demarcation (BCD). The BCD is to distinguish the role of climatic regionalization, specify the basic requirements for architectural construction in various regions, make rational use of climate resources and prevent the adverse effects of climate on architecture.

The BCD work in China began in the early 1980s. The first BCD Standard[1] was published in 1993（GB50178-93). According to the BCD Standard, the country is divided into seven divisions or zones. Different climate zones have different architectural design and construction requirements.

The BCD Standard（GB50178-93）was mainly based on the average temperature in January and July, as well as the average relative humidity in July. So the BCD depends on local climate, especially on local temperature. The BCD Standard in China has been used for 18 years, and the demarcation results are based on the weather data of 1951-1985. This research will focus on whether China's BCD will be affected by the global climate change.

II. CLIMATE CHANGE

A. Global Climate Change

Research shows that China has experienced 19 consecutive warm winters during the past 50 years. Ren et al. studied the evaluation of the earth surface temperature in China. Their research shows that the annual mean earth surface temperature warming rate in China is much higher than the global or hemispheric average growth rate over the same time period (about 1.3 ℃, temperature increase rate is close to 0.25 ℃ / 10 years), with the highest increase rate in winter, which is close to 0.39 ℃ / 10 years[2]. Through statistical methods, Wei Fengying, Cao Hongxing and Wang Liping[3] demonstrated that the trend of the average temperature in China is increasing. They found that China climate change began in the late 1980s with a sharp increase in the 1990s.

There is also much accomplished and ongoing research about climate change in other countries. Vincent Gray[4] pointed out that the air temperature rose 0.7℃ since 1850s, and 0.5℃ since 1950s. Through statistic analysis, Ari Venalainen and Bengt Tammelin[5] concluded that heat demand would reduce 10% from 1961-1990 to 2021-2050; hydroelectric

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power demand will increase 7-11%, while biomass energy demand will increase 10-15% due to climate change. Through statistical methods, David C. Archibald[6] studied the relationship between the emission of CO_2 and the global climate change, and demonstrated that global air temperature rises as the emission of CO_2 increases. Patz[7] studied the impact of climate change on the human environment. Ryunosuke said that water vapor and some other factors may also influence climate[8].

B. Temperature variation of representative stations from 1951-1985 to 1986-2008

The meteorological data used in this paper is from the American National Climate Data Center (NCDC), which is reported to NCDC by meteorological bureaus of different countries and are proved to be reliable. The original data of the updated Typical Meteorological Years used in building energy analysis of 3100 stations by ASHRAE (American Society of Heating Refrigeration and Air Conditioning Engineer) are also from NCDC.

The BCD Standard being used now is based on the weather data of 1951-1985. Because of the meteorological data upload lag, this collection is the use of data for the years 1951-2008, there is no data available for 2009 and 2010. As no data is available for 2009 and 2010, the question may arise about the influence of the missing data on the BCD. This will not be a concern since the BCD is based on the average of many years and there is negligible effect by the data of a couple of single years. In other words, one or two years of data do not significantly affect the demarcation results. On the other hand, data obtained in this research group can continue to examine its impact. Temperature of stations along demarcation and some important cities are considered, and temperature variation from 1951-1985 to 1986-2008 is checked first. Since people have noticed that winter temperatures in various cities in recent years have been low, the figures for temperature variation in different stations along demarcation based on the average temperature of January are shown in Fig. 1-4.

It can be seen that the average temperature of 1986-2008 is higher than that of 1951-1985 for all of the four demarcations. The boundary between zone Ⅰ and zone Ⅱ is called line A, while the boundary line that divides zone Ⅱ and Ⅲ is called line B, zone Ⅲ and Ⅵ makes boundary line C, zone Ⅵ and Ⅶ, Ⅱ, Ⅲ and Ⅴ makes boundary line D. Maximum January temperature variations from 1951-1985 to 1986-2008 of all stations along the four boundaries are 2.6℃, 2℃, 1.3℃, and 2.6℃, respectively, while maximum July temperature variations are 2.2℃, 0.7℃, 0.9℃, and 3.1℃, respectively.

III. NEW CLIMATE DEMARCATION UNDER THE INFLUENCE OF CLIMATE CHANGE

Lines A, B and C are approximately the same in direction and latitude. These three lines are the main focus of discussion in this paper. The main objectives are to analyze the variation of demarcation boundaries, and to investigate

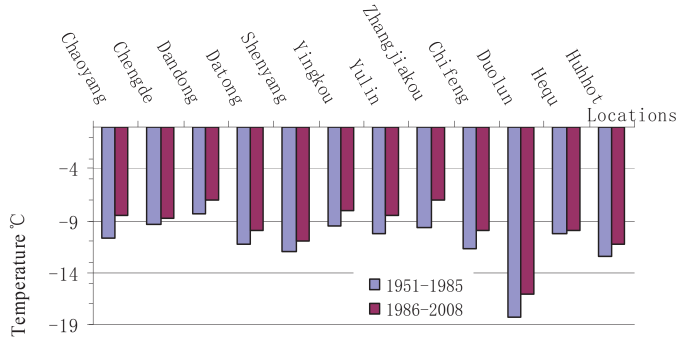

Figure 1 Average temperature variation of stations along demarcation of zone Ⅰ and zone Ⅱ from 1951-1985 to 1986-2008 in January

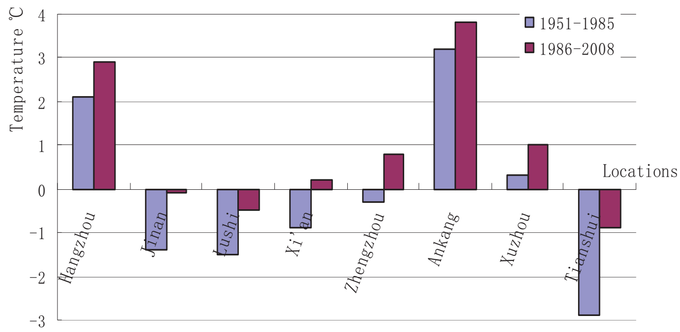

Figure 2 Average temperature variations of stations along demarcation of zone Ⅱ and zone Ⅲ from 1951-1985 to 1986-2008 in January

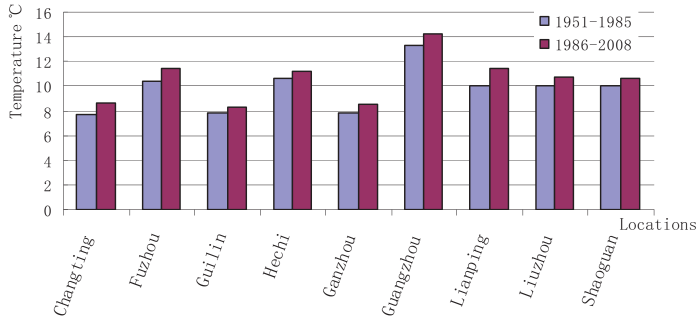

Figure 3 Average temperature variation of stations along demarcation of zone Ⅲand zone Ⅳ from 1951-1985 to 1986-2008 in January

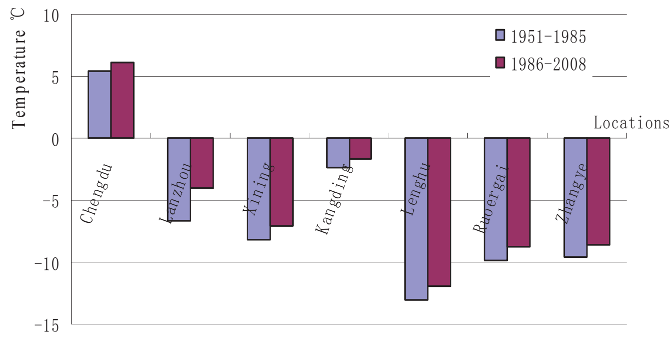

Figure 4 Average temperature variation of stations along demarcation of zone Ⅵand zone Ⅶ, Ⅱ, Ⅲ, Ⅴ from 1951-1985 to 1986-2008 in January

the influence of climate change on the BCD. Stations adopted in this study are the cities along demarcation boundaries and representative large cities.

A. Data history adopted in the analysis

The original zoning is based on the National Weather Service data from 1951 to 1985. The World Meteorological Organization states that the 30-year record is the shortest duration to obtain meteorological characteristics. In this paper, data from the 1979 to 2008 segment of climatic conditions on behalf of climate change in recent years will be used to construct the new BCD boundaries.

B. Analysis of the effects of climate change on the BCD

1) Parameters and terms to create the new BCD

In order to observe the influence of climate change on the BCD, the method to create the new BCD uses the same parameters and terms as used in the original “BCD Standard”. Parameters and terms used are shown in Table 1.

TABLE 1 Parameters and terms used to create the new BCD

BCD zones	Parameters and terms in each corresponding zone
Zone Ⅰ	Average temperature of Jan ≤-10℃； Average temperature of Jul≤25℃； Average relative humidity of Jul≥50%
Zone Ⅱ	Average temperature of Jan -10～0℃； Average temperature of Jul 18～28℃
Zone Ⅲ	Average temperature of Jan 0～10℃； Average temperature of Jul 25～30℃
Zone Ⅳ	Average temperature of Jan ＞10℃； Average temperature of Jul 25～29℃

2) Zoning boundary line

Producing new boundaries shows effects of climate change on the BCD. Terms are simplified so that different sites on the line of two adjacent locations comply with the linear temperature change in the direction of a normal line with an isothermal line. Interpolation temperature error on the line is acceptable.

3) Cities moved from one zone to another

We realize that each of the following locations has changed its zoning from one zone to another adjacent zone by comparing the new with the old BCD boundaries. Locations that have changed their zoning and the largest latitudes that the boundaries moved are shown in Table 2.

TABLE 2 Locations that have changed their zoning and the corresponding largest latitudes that the boundaries have moved

Zone changed	Locations that changed regionalization	Largest latitude that boundaries moved
From zone Ⅰ to zone Ⅱ	Yulin, Zhangjiakou, Chaoyang & the south of Shenyang, Chifeng	Around 1°
From zone Ⅱ Ⅲ to zone	Xi’an, Suzhou, Zhengzhou & the south of Lushi, Puyang, Zaozhuang	Around 30′- 1°30
From zone Ⅲ to zone Ⅳ	Shaoguan & the south of Changting, Guilin, Ganzhou	Around 15′

It can be seen from table 2 that the locations that have changed their zoning exist in all of the three (Ⅰ, Ⅱ, Ⅲ) zones and the largest latitude that the boundaries moved is 1°30′.

IV. CHANGES IN THE IMPLEMENTATION OF BUILDING CODES CAUSED BY DEMARCATION VARIATION

A. The change of building design and construction requirements

Cities in different BCD zones must carry different building design and construction codes. Therefore, building design and construction codes should also be changed when their locations are moved into different zoning demarcation.

B. Building energy efficiency standard alteration

According to the speculation of the "Specification for Medium and Long-term Energy Conservation Plans" issued by the State Development and Reform Committee, all new buildings to be constructed during “the 10th Five Year Plan” period must strictly adhere to meet the 50% energy conservation design standard. In view of this requirement, the residential construction energy conservation standards have been speculated differently for various regions, such as hot-summer-cold-winter region (in correspondence to building climate demarcation standard Ⅲ area), hot-summer-warm-winter area (in correspondence to building climate demarcation standard Ⅳ Area), severely-cold-and-cold area (in correspondence to building climate demarcation standard Ⅰ + ⅥA + ⅥB + ⅦA + ⅦB + ⅦC area, Ⅱ+ⅥC+ⅦD area). Each regional energy conservation standard has specific outer protective structure and energy conservation measures. Because the climatic change causes the change of zoning boundary locations in Table 2, the energy conservation standards must also be changed accordingly.

CONCLUSIONS

This paper uses the last 30 years of meteorological data to reconstruct the BCD using the same parameters and terms as specified in the original "building climate demarcation standard". Compared with the original zoning boundary, the maximum north latitude has moved 1°30' for some locations. Building design and construction codes and energy efficiency standards should also be changed accordingly for those locations. The new BCD standard should designate the valid years, and at the same time the new BCD with the updated weather data should be created accordingly.

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