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Effect of Urbanization in Nantong on Climate Change

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Abstract: According to the meteorological observation data in Nantong, 1951-2010 and the economic and social statistics, this paper studies the correlation between climate change and urbanization, discusses the impact mechanisms of different indicators of urbanization on different climatic factors, puts forward the responsiveness and adaption countermeasures to the climate change that will provide decision-making basis for the realization of the sustainable urban development in the context of climate change in Nantong and draws up the urban planning to respond and adapt to the global climate change for the government and provides a reference for the development strategies on the basis of the analysis of the climate change and urbanization development of the city's nearly 60 years.

Key words: urbanization; climate change; Nantong

1 Study area

Nantong is a city in the north subtropical humid environment, located in the alluvial plain of the downstream of the Yangtze River with about an average altitude of four meters, situated in the region with latitudes raging from 31°41′N to 32°43′N and longitudes 120°12′E to 121°55′E. Regional economic society is situated in the stage of rapid development and the urbanization faces enormous challenges.

2 Data and methods

2.1 Data

The data about urbanization mainly come from *China City Statistical Yearbook* (1985-2011), *Nantong Statistical Yearbook* (1999-2011) and *Jiangsu Statistical Yearbook* (1991-2011), a total of 27 years of data. The meteorological data during

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1961-2010 is mainly used from the weather stations in Nantong in Jiangsu province. In this paper, the missing data are filled by using the linear trend interpolation method.

2.2 Methods

For analyzing the level of urbanization, the trend of climate change and the relationship between urbanization and climate change, analytic hierarchy process (AHP), moving average and estimation of linear tendency are used in this paper.

3 Effect of urbanization on climate change

Considering the average level of Beijing and Shanghai as the optimal level of urbanization through analytic hierarchy process, the level of urbanization in Nantong is analyzed. The results show that: now the ratio of urbanization in Nantong is 80%, where the levels of urbanization of economy and social life are higher, and also close to the standard level. The levels of urbanization of population and geographical landscape are about two-thirds of the standard level. Among each single indicator, the levels of development of the output value of secondary industry to GDP, road area per capita, residential area per capita, water penetration ratio and urban gasification ratio are higher, which are above or close to the optimal level. However, compared with the optimal level, the levels of green coverage area, annual electricity consumption, the number of buses per ten thousand people and the number of college students are low.

In the past 60 years, the average temperature is rising at the rate of 0.297□/decade, where the warming trend in spring is the most significant, and that in summer is the least. The trends of the min-mean and max-mean temperature are on the rise. Over the past 60 years, the tendency of precipitation is generally on the rise with the small rate. The increasing trend of precipitation in summer is the most pronounced, followed by winter. Precipitation in spring and autumn is slightly decreasing. The contribution of the increase in precipitation mainly derives from the addition in summer and winter. On the basis of the analysis of the development of urbanization and the trend of climate change, the influences of urbanization on temperature and precipitation are analyzed by using estimation of linear tendency.

3.1 Effect of urbanization on temperature in Nantong

In Fig.1, Fig.2 and Table.1, it can be found that: the correlation between the change of temperature and population is large, but the correlation between temperature and built-up area is small. At the seasonal scale, the correlation between the tendency of temperature in spring and population is the largest, the second is autumn, and the correlation in winter is the smallest. Among the correlations between built-up area and the trend of temperature, summer and autumn are the largest, and winter is the least. In other respects, the correlation between population and max-mean temperature

is the most significant, but the correlation between population and extreme minimum temperature is the least. The correlation between built-up area and extreme maximum temperature is the largest, and that between built-up area and min-mean temperature is the smallest. It can be observed that the relations between the increase of population, the expansion of built-up area and the trend of temperature are noticeable, where the effect of population on temperature is larger compared with the expansion of built-up area, which is the major reason for the increase of temperature in Nantong.

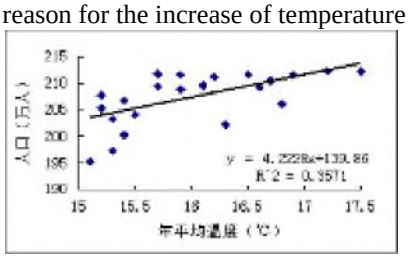

Fig.1. The relationship between mean temperature and population in Nantong

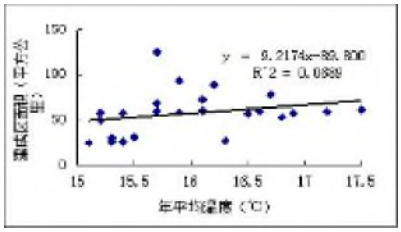

Fig.2. The relationship between mean temperature and built-up area in Nantong

Table 1. the correlation coefficients between other indexes of temperature and population and built-up area in Nantong

	Spring	Summer	Autumn	Winter	Min-mean temperature	Max-mean temperature	Extreme minimum temperature	Extreme maximum temperature
Population	0.406	0.2073	0.3194	0.0374	0.192	0.5141	0.0018	0.247
Built-up area	0.0492	0.0735	0.0656	0.0044	0.006	0.1931	0.0254	0.2001

Since the reform and opening up, especially in the middle and late 1980s, the rapid development in Nantong has been implemented. The urban population in Nantong has exceeded 2.1 million. At the same time, the built-up area is constantly expanding, from 25 square kilometers in 1987 to 125 square kilometers in 2010, an increase of four times. The continuous development of urbanization contributes to the extension of road area, the considerable increase in the number of various types of vehicles and the rapid development of different industries such as textile, petrochemical, chemical, construction and port et al. The rising tendency of urban temperature derives from the rapid development of city, the continuous increase of urban population, the expansion of urban area and the more and more emissions of anthropogenic heat.

3.2 Effect of urbanization on precipitation in Nantong

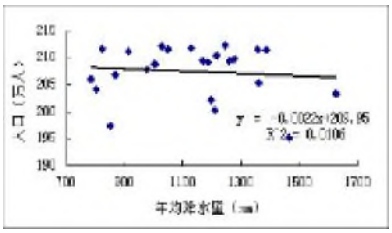

Fig.3. the relationship between average precipitation and population in Nantong

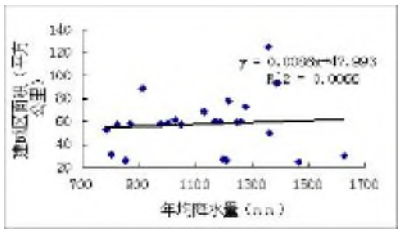

Fig.4. the relationship between average precipitation and built-up area in Nantong

Table 2. the correlation coefficients between precipitation at seasonal scale and population and built-up area in Nantong

	Spring	Summer	Autumn	Winter
Population	0.0001	0.003	0.0048	0.0293
Built-up area	0.0006	0.0031	0.0054	0.0292

From Fig.3, Fig.4 and Table.2, it is observed that the correlation coefficients between the increase in urban population and the expansion of built-up area and precipitation are small without obviously direct linear correlation, so the impact of that on precipitation in Nantong is not very distinct. The influence of urbanization in Nantong on precipitation mainly derives from the effect on temperature. Heat island effect resulted from the increase in temperature is conducive to the formation of thermal convection, thereby forming convective precipitation. The increase in types of high-rise buildings in city may cause the mechanical turbulence, thus slowing down the movement of the system of precipitation, resulting in the enhancement of intensity of precipitation and the extension of the time of rainfall. It is found that the direct effects of population and built-up area on climate change in Nantong are small and negligible whose correlation coefficients are 0.0022 and 0.0086, respectively, which is different from Nanjing and Ningbo. Meanwhile, this paper reveals that the impact of the development of city on precipitation is a multi-disciplinary result that is not merely determined by one aspect.

4 Conclusions

This paper studies the city with the rapid development of economy, Nantong. Through the analysis for the period of nearly 30 years of the correlation between the process of urbanization and climate evolution in Nantong, the effect of the development of urbanization on climate change is further explored. Results show that there is a certain influence of urbanization on climate change in Nantong. During the twenties years of the rapid development of urbanization in Nantong, mean temperature, max-mean temperature, min-mean temperature and average precipitation suffered different degrees of rise, and the correlation between urbanization and climate change is larger. But the direct effect of urbanization on precipitation is not significant with a very small correlation.

