

Formation of urban heat island and its effect over temperature variability in Babol

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Extended abstract

Introduction

Urbanization and cities have a great impact on human life. Today, more than half of the world's population living in cities. One of the important impacts of the city is the change in environmental characteristics. Changes due to urbanization have negative consequences on environmental, social and economic characteristics. Cities reduce the amount of albedo and emissivity of the ground.

Due to changes in the radiation balance in cities, one of the consequences of their development is the change in temperature characteristics of environment. The most famous city's impact on the climate is the urban heat island (UHI).

Mostly, cities have higher minimum temperatures from suburbs. In addition to the temperature differences between the city and the suburbs, some studies have shown that the behavior of urban areas is also different. UHI is one of the most important factors in increasing energy demand for cooling in buildings. The effect of UHI was observed in London in the 1830s first, and then this phenomenon was studied in other European cities and large American cities such as Chicago and New York.

UHI can be detected better at a minimum temperature. In addition to the temperature differences between the city and the suburbs, some studies have shown that the temperature behavior of urban areas varies with other environments.

Because of harmful effects of UHI, humans have always sought a solution to reduce urban heat island intensity. Major researches about urban heat island have been done in the metropolises of developed and developing countries.

Babol is the second largest city in Mazandaran province. This city has rapid population growth since 1956. With its rapid expansion, it is considered an intermediate or medium size city now, and the creation of UHI in this city is expected. The purpose of this study is to investigate the formation of UHI and its effect over day to day changes in temperature of Babol. This work try to understand the best time of UHI formation in Babol every day, as well as looking this at the best time between different months of the year.

Materials & Methods

This study was conducted on Babol city in Mazandaran province. The increase in population from 36,194 people in 1956 to 356,781 in 2015 indicates the high physical development of Babol, in recent decades. This increase in population over the past decades has led to an increase in unplanned construction, change in the physical model of the city and its expansion in various directions. During the last three decades, after Sari, Babol has had the largest physical development.

There are several methods of identifying UHI, which typically include the use of climatological data from the environment, satellite imagery, or mathematical modeling. Due to the lack of professional urban meteorological station in Babol, two sets of data logger (MIC 98583 USB-Data Logger, Taiwan) with the ability to record temperature and relative humidity data at different times in the city and suburbs were installed.

The first place in the city center, which has high population density and high traffic per day, was selected as urban station. The second place was located as a suburban space in the southern part of the city. The sensors were placed in wooden boxes. These boxes were placed at an altitude of about 2 m from the ground. These devices were calibrated by the manufacturer and tested at the meteorological station before starting up the devices in the environments.

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The conventional method was used to illustrate the urban heat island intensity. The temperature difference between urban center and surrounding rural areas (ΔT_{u-r}) indicates the intensity of urban heat island. According to references, sometimes the urban heat island intensity in some cities will reach more than 10°C .

Also, this research investigated day-to-day temperature variations in both urban and suburb locations to show spatial differences. For this purpose, the two following integrated methods were used: 1) The day to day temperature variation (DTD), 2) the difference between day to day variability of daily maximum temperature (DTD_{max}) and day to day variability of daily minimum temperature (DTD_{min}) (Tam et al., 2015).

The day to day temperature variation is based on Equations (1).

$$\text{DTD} = \sum |t_i - t_{i-1}| / (n - 1) \quad (1)$$

where Σ is the sum over all n data elements, t is daily temperature, i is the counter that marches through the days in a time period (e.g. a month), $||$ is the absolute value, and n is the number of days elements.

$$\Delta\text{DTD} = \text{DTD}(t_{\text{max}}) - \text{DTD}(t_{\text{min}}) \quad (2)$$

ΔDTD is the difference between day to day variability of daily T_{max} (DTD_{max}) and day to day variability of daily T_{min} (DTD_{min}). Its positive values indicate more changes in temperature for days, and negative values indicate higher temperature variations for nights. In rural areas, minimum temperature day to day variability is higher than the maximum temperature day to day variability.

Mostly, in urban areas, the ΔDTD is more than rural area.

Results & Discussion

To understand the temperature behavior of the city and suburb, hourly temperature data were extracted for two environments. The survey showed that from 9 to 13, the intensity of the UHI has lowest amount. The lowest temperature difference is around 11 am. In other words, the city's impact on temperature is at its lowest amount at this time. In general, the average temperature in the urban environment is about 19.5°C and in the suburb it is 18.5°C .

In addition, during December, January and February the temperature difference between the city and the suburbs, which is more than other months. In these months, the difference between two urban and suburbs minimum means temperature reaches more than 2.5°C . While the difference of maximum temperatures of the two points isn't high, and in some months these indicators are in the suburbs more than the city.

The UHI intensity according to minimum temperature is 1.7°C throughout the entire survey period. In addition, temperature difference between the city and the suburbs was more pronounced during December, January and February. The survey showed that DTD for mean daily temperature and minimum temperature in city is more than the suburbs, but this index for the maximum temperature is not much different in the two environments. The city's ΔDTD is higher than the suburbs. The study of the urban and suburb humidity showed that the urban average is about 70% and the suburbs also have about 73% relative humidity. There is the highest humidity difference between the urban and the suburbs in the morning, because at this time suburbs having a lower temperature than the city.

Conclusion

The present study, based on observed data in two urban and suburban areas in Babol, has been studying the temperature differences for urban heat island behavior.

According to the findings of the discussion, it seems the temperature difference between the city and the countryside observed in Babol is due to the effect of the city on the temperature. In other words, the UHI is formed in the city, and this phenomenon is clear in minimum temperatures. The results of the temperature study in Babol showed that the minimum temperature in every month was higher than suburbs, while the maximum temperature of urban in many cases was less than the suburbs. In the urban station during the period under review, the minimum temperature has not fallen below 2°C , and in the suburbs the lowest recorded temperature is -0.8°C . The study of the daily variability of temperatures also showed that the ΔDTD index, which is a new and alternative indicator for identifying the UHI phenomenon, is lower in the suburbs. Since the built up environment reduces the amount of albedo and emissivity from the ground, and it is generally less moisture and the heat and energy reaches a higher level, more Tangible heat will be stored within the built-up space.

According to the findings of the discussion, it can be said that the temperature difference between the city and the suburbs is as a result of the city's effects on the temperature. In other words, the thermal island in Babol has been formed and this mode has been shown more clearly in its minimum temperatures.

Keywords: Babol, heat island, minimum temperature, urban, variability.