Analysis of the Urban Heat Island Spatial Variability over Tehran

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Extended Abstract

Introduction

The Urban Heat Island (UHI) effect refers to the temperature rise of any man-made area. It is a phenomenon in which cities become warmer than the surrounding suburbs. In other words, there is a temperature difference between the cities and the area surrounding them. Generally, the UHI effect could be a result of excessive and unplanned growth of urbanization. The behavior of artificial urban texture in terms of absorption of short-wave and long-wave radiation, transpiration, releasing of anthropogenic heat, and blocking prevalent wind is significantly different from that of the rudimentary nature. Surface geometry on the other hand, decreases wind speed in urban regions which plays a great role in formation of UHI. As the energy balance inside a city alters, UHI intensity varies. This means that UHI intensity is not spatially and temporally similar in different cities. Also it must be noticed that UHI formation in a city usually has diurnal or seasonal patterns which are mostly affected by synoptic weather conditions. There are three main synoptic and local climatology parameters affecting UHI formation: air pressure systems, cloudiness, and wind speed. Under stationary high-pressure system conditions temperature differences between urban and rural areas become large. UHI intensity is largest in calm air and cloudless sky conditions and tends to disappear in cloudy and windy weather.

The urban heat island can lead to urban temperatures being 2–5 ˚C higher than those in rural surroundings. Studies have shown the difference in temperature between urban and rural regions (UHI Intensity: ΔT_{U-R}) is revealed in minimum temperatures rather than maximums. TheMaximum UHI intensity usually occurs 3–4 hours after sunset in the urban area. Other impacts of the UHI could be intensifying pollutant concentration over urban areas, altering local wind patterns, increasing humidity, forming cloud and fog, and changing the precipitation rate over a city.

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Methodology

In this study, the urban heat island over Tehran was analyzed. Tehran is the largest and the most populated city of Iran, with an approximate area of 750 Km^2 and a population of 8 Million during night time. The city lies almost in the middle of the Tehran province (1882 Km^2 of area) in the southern side of the Alburz Mountain and is limited to the highlands in northern and eastern parts. On the southern and western parts, it is connected to the flat plains of Varamin, Shahriar and Karaj.

To investigate the spatial and temporal patterns of the UHI over Tehran, after studying the literature reviews and earlier studies, 24 days from the year 2006 were chosen; two days of each month, one day with the highest and the other with the lowest air pressure over the urban area were chosen. Then, the climatologic data (including temperature, cloudiness, air pressure, wind direction and wind speed) for each day were gathered from different data sources: 1- Iran Meteorology Organization stations including synoptic and climatology stations, 2- Air quality measuring stations including Air Quality Control Company[1] and Department of Environment[2] stations.After data refinement, in order to choose the sample days for UHI illustration, primary maps were drawn using ArcGIS 9.3, then 216 maps were drawn (9 maps with 3 hours interval for each day); also, for a better perception of the temporal patterns of the UHI, the measuring times were transformed from Greenwich Mean Time (GMT) to the Local Time (LT) by adding 3:30. The difference between the average temperature of the urban district (T_U) and the rural area (T_R) was calculated by MS Excel 2007 for collecting the UHI intensity during different seasons and months and for all 24 days at each measurement hour. In the next step, due to primary results four typical days were chosen to represent each season. Aside from the obtained data from the surface measurement stations, the Air Pollution Model (TAPM) was employed to compensate the lack of data on the rest of the study area by modelling the wind field (i.e. wind direction and speed) over the study area. Therefore, all hours in chosen days were modeled with a 10 kilometers resolution with synoptic that shows the actual wind condition. Finally, integrated maps were drawn which the final analysis were based on.

Results and Discussion

Results show that an increase in the wind speed causes a reduction in the UHI intensity, also in high-speed winds (4 knot and up) the formation of the UHI tends to disappear. Moreover, no significant correlation was found between the air pressure and the UHI intensity and formation. Only in summer, and in the high pressure conditions, maximum intensity has occurred at 00:30, and in the low pressure condition the minimum intensity occurred at 09:30. Also, the summertime UHI intensity is much higher than the wintertime intensity. The spatial variation of the UHI does not seem to have a regular pattern, because it varies in different seasons and months. Totally, the spatial extent of the UHI is limited by the wind direction and velocity.

1. AQCC
2- DOE

Conclusion

The spatial variation of the UHI seems to be significantly affected by the wind velocity. Hence, in order to determine the main thermal core of the UHI, the wind field must be considered. The results have shown that the distribution of the heat island main cores during the year, is mostly dependant on the wind velocity. However, it could be concluded that the main core of the UHI is usually located somewhere between Mehrabad, Fatemi, Bahman, and DoushanTappeh Stations. Also during different months, Bazaar, Bahman and Azadi Stations mostly show a higher temperature in comparison to their surroundings.

Keywords: Urban Heat Island, Spatial Variation, Wind Field, Tehran.