Urban Climate xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Urban Climate

journal homepage: www.elsevier.com/locate/uclim

Surveying of Heat waves Impact on the Urban Heat Islands: Case study, the Karaj City in Iran

Asad Ghobadi, Mahmood Khosravi*, Taghi Tavousi

Department of Physical Geography, University of Sistan and Baluchestan, Zahedan, Iran

ARTICLE INFO

Keywords:
Heat wave
Synoptic pattern
Urban heat island
Humidity conditions
Karaj city

ABSTRACT

From July 6th to August 5th of 2014, a severe heatwave happened in Iran. This study analysis the formation and relative effect of this heatwave event on the environmental situation in the Karaj city (west of Iran capital). This city has experienced warm summers and high amounts of heat-related mortality. This research is accomplished according to the statistical-synoptic-approach and mobile survey data. Two main data sets are collected during this event from 20 stations in the urban and rural areas. The results of data are derived from hierarchical cluster analysis by using Ward's method. Analysis of mid-level synoptic charts demonstrate a low pressure at ground level in North West of India (Gange's thermal low pressure) which covers the case study area together with a high-pressure system that dominates in the middle levels. This phenomenon affects the thickness of the atmosphere and causes warm air subsidence, abnormal air heating and a stable urban heat island (UHI) in the region. Compared to the rural areas, the temperature of the city is about 1 °C warmer within the day times and up to 2.5 °C warmer at nights. Furthermore in comparison with the rural areas, in urban environment the temperature value combination of surrounding humidity stations, determined systematically warmer status. This intensity of UHI is the simplest and most quantitative indicator of the thermal modification imposed by the Karaj city upon its territory, and shows its relative warming compared to the surrounding rural environment at night times.

1. Introduction

Heatwave patterns and urban heat island phenomena have influenced environmental conditions by creating numerous problems in societies. Most of the human activities are sensitive to extreme temperature (Cox and Tikvart, 1990). Heat waves are the main point of the contemporary global climate changes that are caused damaged to live and properties in terms of its frequency of occurrence (Cohen, 2008). In meteorological terms, a heat wave is defined as a prolonged period of unusually hot weather (Hajat et al., 2002; Diaz et al., 2002; Kyselý, 2004; Michelozzi et al., 2004).

Statistically, heat waves imply to make positive fluctuation over the mean daily temperature that is continuity referring to consecutive days (sometimes weeks or months) in certain geographical spaces. According to definition, two factors of time and geographical region have become more important for occurrence or non-occurrence of heat waves. For example, high temperature upper than 24 °C is the heat wave threshold in the UK, but in Iran this threshold is much higher. The heat wave threshold is about 42 °C when the high temperature is continued for at least two days or more. In classification of environmental hazards, heatwave is the subgroup of extreme temperatures (Oke et al., 1999).

* Corresponding author.
E-mail addresses: A_ghobadi@Pgs.usb.ac.ir (A. Ghobadi), khosravi@Gep.usb.ac.ir (M. Khosravi), t.tavousi@gep.usb.ac.ir (T. Tavousi).

https://doi.org/10.1016/j.uclim.2017.12.004
Received 26 September 2016; Received in revised form 3 December 2017; Accepted 11 December 2017

Urban heat island (UHI) is a well-known and thoroughly researched phenomena in urban climatology. In certain cities of the temperate climatic zone, structures and features of the UHI are well documented (Jerome et al., 2005; Kovatsand and Hajat, 2008). A higher urban-rural temperature forms the basis of UHI effect, which is a common urban phenomena (Arnfield, 2003).

Studies about UHI illustrate that temperature difference between municipal, rural and suburb areas is more obvious in minimum temperature condition (Bulut et al., 2008; Süleyman and Yilmaz, 2010). A number of reasons for this temperature differences can be the release of anthropogenic global warming (B. Zhang et al., 2014; N. Zhang et al., 2014), increase in urban pollution layer by absorption of longwave radiation emitted from the surface of that part will emit to the surface of land again (Shahmohamadi et al., 2011). Geometry of the cities with high buildings creates a unique three-dimensional edifice by producing air stagnation or slow speed of wind which in return creates lower cold air entrance to cities, changing the in land shield, spoiling vegetation, forming impermeable surfaces. Constructed materials such as asphalt and concrete have upper heat capacity and thus decrease evaporation, transpiration and release the absorbed energy slowly (Grize et al., 2005). The UHI intensity is greatest when it is under system conditions of stationary high-pressure, stable air and clear sky. This tends to disappear if cloudiness and wind speed increases.

Unprecedented heat wave in 2014 has brought many damages to Karaj city. The objective of present study is to determine if urban heat islands are present or not and to confirm whether any apparent urban-rural differences are statistically significant. Moreover, this study will identify circulation patterns in superheat days through synoptic approach. Then the UHI's impact on the environmental conditions of the Karaj city will be quantified and it will be shown how human health conditions could be exacerbated due to the intense UHIs. Heat waves will exacerbate by urban heat island effect which in return could have this potential to negatively influence the health and welfare of urban residents. In Section 2 we will bring materials and methods in which a brief discussion about importance and motivation of study for the chosen area is brought up and tools which used to investigate the question of study are fully described. Then in the third section findings and results of this work are fully discussed and addressed, and finally in Section 4, conclusions are brought up.

2. Materials and methods

2.1. Research background

The increase of extreme climatic conditions is either the most important and as well, the worst effect of global warming. There exist significant relations between heat wave occurrence and mortality (Susanna et al., 2007). UHIs are associated with thermal and hygrometric discomfort because of the rise in temperature (Amorim, 2005). Correlation of atmospheric processes and Heat Waves involve significant mid troposphere anomalies that extended periods of subsidence and clear skies, light winds, warm-air advection prolonged normal temperature (Meehl and Tebaldi, 2004). In various sources, the frequency of heat waves incident in the years is considered as one of the climate change outcomes in the frame of extreme climate (Hajat et al., 2005). Gartland and Ilhas (2010) has pointed out that not only do heat islands cause minor additional discomfort, but also the higher temperature and lack of shading and the consequent increase in air pollution increase the mortality rates and affect the population health.

The fourth report of the Intergovernmental Panel on Climate Change (IPCC, 2007) emphasizes that climate changing will be faster in the coming century (Keller, 2007; Solomon et al., 2008). Therefore, the human threats of climate change need to be strongly considered as a public health issue and it may be the biggest global health threat in future (Costello and Costello, 2009; Haines et al., 2006).

Determining tendency tried to assess the attributed extreme temperature-mortality after two-heat-wave events in the United States in 1965 and 1999 (Kunkel et al., 1996). During 1999, approximately 80% of all deaths were in urban regions (including Kansas City, Milwaukee, and St. Louis) (Whitman et al., 1997; Medina-Ramon and Schwartz, 2007). Similarly, excess deaths related to heatwave event in many European cities during 2003 (Sardon, 2007; Robine et al., 2008; Weissekopf et al., 2002).

Therefore, this event has been well documented by developed countries and issued as the preventable public health priority in developing worlds. Also, different studies are examined by Huang et al. (2010) about the heat wave event effect on mortality related to Shanghai in 2003. Khalaj et al. (2010) have examined heat wave effects on the health in the five districts of New South in the Australia. Study of Synoptic conditions for an intense heat wave of Argentinian in March 1980, Represents an anticyclone circulation at different levels of the troposphere and Heatwave was more severe because of the presence of a stable atmosphere in the Buenos Aires. Camilloni and Barrucand (2012) and Seluchi et al. (2006) have analyzed Synoptic and thermodynamic dimensions of heat waves in the subtropical regions of South America that indicate climate stability factors, temperature advection and humidity in the heat waves event. Chen and Konrad (2006) have mentioned that the presence of Bermuda High pressure, warm and moisture of Atlantic Ocean advection, a ridge in intermediate levels and Adiabatic heating in middle levels of the troposphere are the main cause of the concise heat wave in North Carolina. Unkašević and Tošić (2009) have analyzed the heat wave continuation in the summer (16 days) and 21 days in the Nish city of Serbia by using geo-statistics method. Also, a continuation of Belgrade heat wave (18 days) in 1994 has known as the longest heat wave in the Serbia. According to the study of Greek Severe heat wave in 2010, it is proved that blocking system occurrence has caused stability of pollutants. Therefore, inactivity Followed by hot weather and pollution are created a very unhealthy climate in Greece (Theoharatos et al., 2010, other Studies have shown that the severe heat waves are happened By increasing the surface temperature of Mediterranean Sea, the North Sea and the northern parts of Arctic Circle in Europe (2003) and occurrence of blocking system in the lower, middle and upper troposphere was the main reason for continuation of The severe heat wave (Feudale and Shukla, 2011). Lelovics et al. (2013) used mobile measurements to examine thermal variations in Szeged, Hungary. The average UHI magnitudes derived here were consistent with their results, especially the ones for sparsely built areas, with magnitudes under 1 °C. Puliafito et al. (2013) discovered the effects of green areas and micro scale thermal comfort in in