Mass Human Migration and the Urban Heat Island during the Chinese New Year Holiday: A Case Study in Harbin City, Northeast China

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Received 5 November 2014; revised 3 December 2014; accepted 4 December 2014; published 16 March 2015

Abstract Many Chinese people leave big cities for family reunions during the Chinese New Year (CNY), which is the most important public holiday in China. However, how modern mass human migration during the CNY holiday affects the urban heat island (UHI) is still unknown. Here, the authors investigate the role of modern human migration for the UHI effects during the CNY holiday for the period of 1992–2006 in Harbin City, Northeast China. The results show that during the CNY week, the UHI effects expressed as daily mean, maximum, and minimum temperature differences between urban and rural stations averaged over the period of 1992–2006 are 0.65°C (43%), 0.31°C (48%), and 1.14°C (71%) lower than during the background period (four weeks before and four weeks after the CNY week), respectively. Our findings identify previously unknown impacts of modern mass human migration on the UHI effects based on a case study in Harbin City.

Keywords: urban heat island, Chinese New Year holiday, mass human migration, surface air temperature, Harbin City
Citation: Wu, L.-Y., J.-Y. Zhang, and C.-X. Shi, 2015: Mass human migration and the Urban Heat Island during the Chinese New Year holiday: A case study in Harbin City, Northeast China, *Atmos. Oceanic Sci. Lett.*, **8**, 63–66, doi:10.3878/AOSL20140087.

1 Introduction

The altered land surface and anthropogenic heat release increase the sensible heat flux from the land surface to the atmosphere in city areas, leading to higher temperatures than in surrounding rural areas—a phenomenon known as the urban heat island (UHI) (Howard, 1820; Balchin and Pye, 1947; Oke, 1982; Gordon, 1994; Kalnay and Cai, 2003; Li et al., 2004; Zhang et al., 2005; Liu et al., 2007; Ren et al., 2007; Miao et al., 2009; Oleson et al., 2010; Yang et al., 2013; Georgescu et al., 2014). The UHI can not only produce detrimental impacts, such as degradation in air quality and water quality, amplification in heat waves and storms, and increases in energy demands for air conditioning in summer (e.g., Weaver et al., 2009; Milojevic et al., 2011; Myhre et al., 2013), but also beneficial effects, such as less demands for heating in winter (e.g., Taha, 1997; Stewart and Oke, 2012). Therefore, it is important to understand the nature and causes of the UHI, to develop mitigation or adaptation strategies in the future.

The Chinese New Year (CNY), the beginning of the lunar New Year, is traditionally China's most important public holiday, officially lasting for one week. Since Reform and Opning-up, many people from rural or underdeveloped areas have migrated to big cities. During the CNY holiday, many people in big cities return to their native places for traditional family gatherings.

The reduction of the urban population during the CNY holiday decreases human activities in urban areas, thus leading to reductions in anthropogenic heat emissions from such as vehicles, heating, industrial energy consumption, and human metabolism. The effects of anthropogenic heat on the UHI are relatively large in mid- and high-latitude cities in winter due to weaker solar radiation input, shallower boundary layer, and greater energy use for heating (KŁysik, 1996; Ichinose et al., 1999; Fan and Sailor, 2005; Bohnenstengel et al., 2014). Less human activities can also directly and indirectly affect other processes and thus change the UHI (Bonan, 2008). However, how the mass human migration affects the UHI during the CNY holiday is still unknown.

Harbin City is the capital of Heilongjiang Province, Northeast China, and covers the area from 44°04'N to 46°40'N and from 125°42' E to 130°10'E. The city is known for its coldest climate and longest winter among the major cities of China. Harbin City is a key cultural, political, economic, and scientific center in Northeast China. It has experienced a rapid growth in population from 4.22 million in 1990 to 9.80 million in 2006. Migrant workers and college students usually leave the city for family reunions before the CNY holiday. Also, some local residents leave the city for visiting their relatives and friends, or other purposes. This study investigates the role of modern human migration for the UHI during the CNY holiday in Harbin City for the period of 1992–2006.

2 Data and method

The homogenized daily mean (T_{mean}), maximum (T_{max}) and minimum (T_{min}) temperatures used in this study are obtained from the China Meteorological Administration. The UHI effect is defined as the temperature differences between urban (Harbin) and rural (Fangzheng) stations ($\Delta T = T_{urban} - T_{rural}$). The description of the two stations is

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provided in Table 1.

The CNY day is determined according to the lunar calendar, therefore, the date of the CNY day changes with year. Table 2 shows that the date of the CNY day varies between 22 January and 19 February during the period of 1992–2006. In this study, the CNY day is denoted as day +1, and the day before as day −1. The CNY week is from day +1 to day +7. Our study period includes nine weeks from 28 days before to 34 days after the CNY day. The dates of the CNY day, the CNY week, and the start (day −28) and end (day +35) days of the study period are listed in Table 2.

3 Results

Figure 1 shows daily mean (ΔT_{mean}), maximum (ΔT_{max}), and minimum (ΔT_{min}) temperature differences between urban and rural stations from 28 days before the CNY day (day −28) to 34 days after the CNY day (day +35) averaged over the period of 1992−2006 in Harbin City. ΔT_{mean}, ΔT_{max}, and ΔT_{min} from day −28 to day +35 show a similar feature. All three temperature variables have relatively lower values during the CNY week. Meanwhile, some differences exist. ΔT_{mean} ranges between 0.37°C and 3.11°C, and the mean value is 1.43°C for day −28 to day +35. During the CNY week (day +1 to day +7), ΔT_{mean} is lower than the mean value. ΔT_{max} values during day −28 to day +35 exhibit smaller magnitudes than ΔT_{mean} with a mean value of 0.62°C, and during the CNY week, they are lower than the mean value except on day +1. Comparatively, ΔT_{min} has the larger magnitude than ΔT_{mean}, varying from −0.26°C to 3.36°C during day −28 to day +35. ΔT_{min} during the CNY week is much lower than the mean value of 1.49°C.

Since the CNY holiday officially lasts for one week, we further examine the weekly means of ΔT_{mean}, ΔT_{max}, and ΔT_{min} during day −28 to day +35 averaged over the period of 1992–2006 (Fig. 2). Here, we define the CNY week as week +1, one week before as week −1, one week after as week +2, and so on. ΔT_{mean} has the lowest value of 0.86°C in the CNY week, and the weekly mean ΔT_{mean} values fluctuate between 1.25°C and 1.71°C in non-holiday weeks. ΔT_{min} is much stronger than ΔT_{max} in non-holiday weeks. However, during the CNY week, ΔT_{max} and ΔT_{min} only have small differences with magnitudes of 0.48°C and 0.34°C, respectively. Therefore, the reduction of ΔT_{min} is much larger than that of ΔT_{max} during the CNY week, compared to non-holiday weeks.

To further compare the UHI differences between the CNY holiday and non-holiday times, we define four

Table 1 The description of urban and rural stations.

	Harbin	Fangzheng
Latitude (°N)	45°45'	45°51'
Longitude (°E)	126°46'	128°51'
Altitude (m)	143	119
Location	Urban region	Rural region

Table 2 Dates of the Chinese New Year (CNY), CNY week, 28 days before the CNY day (day −28), and 34 days after the CNY day (day +35) from 1992 to 2006.

Year	CNY day	CNY week	Day −28	Day +35
1992	4 February	4–10 February	7 January	9 March
1993	23 January	23–29 January	26 December	26 February
1994	10 February	10–16 February	13 January	16 March
1995	31 January	31 January – 6 February	3 January	6 March
1996	19 February	19–25 February	22 January	24 March
1997	7 February	7–13 February	10 January	13 March
1998	28 January	28 January – 3 February	31 December	3 March
1999	16 February	16–22 February	19 January	22 March
2000	5 February	5–11 February	8 January	10 March
2001	24 January	24–30 January	27 December	27 February
2002	12 February	12–18 February	15 January	18 March
2003	1 February	1–7 February	4 January	7 March
2004	22 January	22–28 January	25 December	25 February
2005	9 February	9–15 February	12 January	15 March
2006	29 January	29 January – 4 February	1 January	4 March

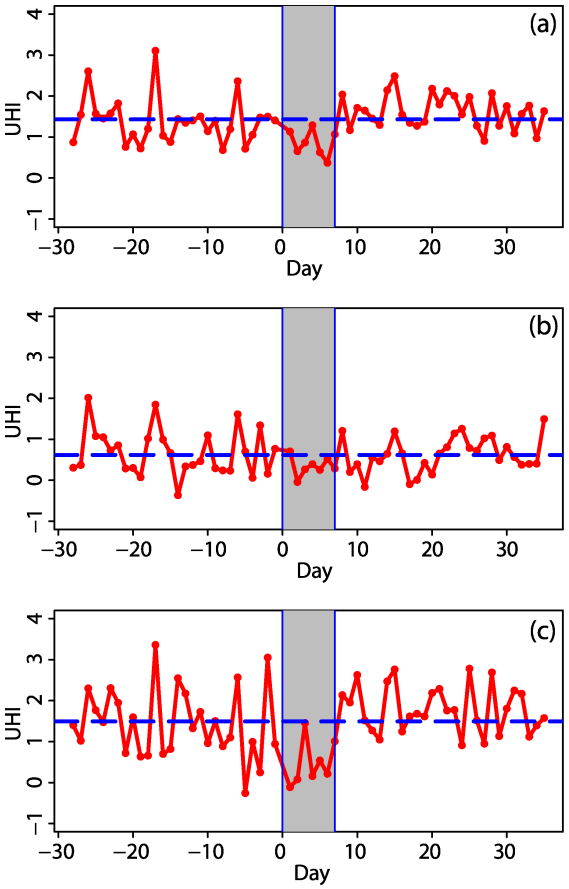

Figure 1 The urban heat island (UHI) effects from 28 days before the CNY day (day −28) to 34 days after the CNY day (day +35), averaged over the period of 1992–2006 in Harbin City: (a) ΔT_{mean}, (b) ΔT_{max}, and (c) ΔT_{min}. ΔT_{mean}, ΔT_{max}, and ΔT_{min} represent the daily mean, maximum, and minimum temperature differences between urban and rural stations, respectively. The UHI effect during the CNY week is highlighted by the gray shaded area, and the blue dashed line represents the mean UHI value for day −28 to day +35.

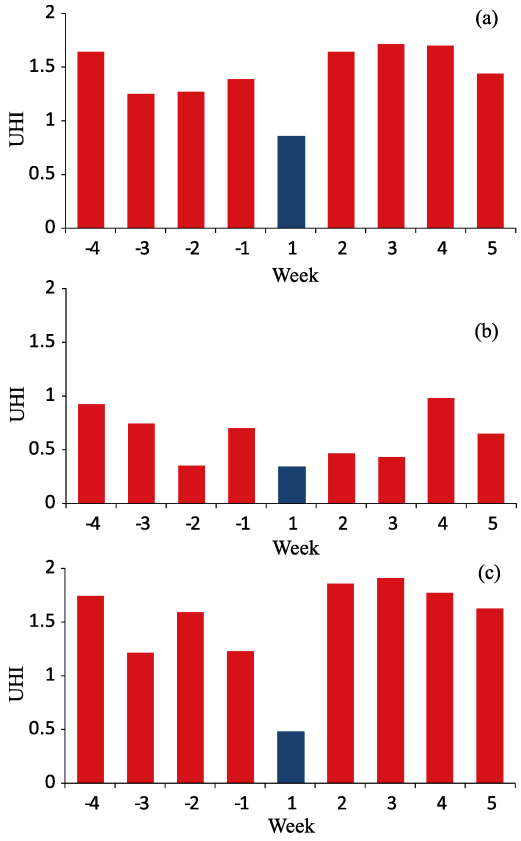

Figure 2 Weekly means of the UHI effects during day −28 to day +35 averaged over the period of 1992–2006 in Harbin City: (a) ΔT_{mean}, (b) ΔT_{max}, and (c) ΔT_{min}. The CNY week is denoted as week +1, one week before as week −1, one week after as week +2, and so on.

weeks before and four weeks after the CNY week as the background period. Table 3 lists the values of the UHI during the CNY week and the background period, the differences between them, and the relative changes of the UHI during the CNY week to the background period averaged over the period of 1992–2006. ΔT_{mean}, ΔT_{max}, and ΔT_{min} during the CNY week are consistently much lower than during the background period. The differences between them are 0.65°C, 0.31°C, and 1.14°C, respectively. The relative changes of ΔT_{mean} and ΔT_{max} during the CNY to the background period have the similar value of 43% and 48%. Comparatively, the change of ΔT_{min} can reach 71%. The differences in ΔT_{mean} and ΔT_{min} are significant at the 99% confidence level by Student's *t*-test, and the ΔT_{max} difference is significant at the 98% confidence level.

4 Conclusions

Harbin City, located at the highest latitude, has the coldest climate among major cities in China. The city has undergone rapid urbanization in the last decades. During the CNY holiday, many people in the city return to their native places or leave for other purposes for celebrating the most important Chinese holiday. This provides us an unique opportunity to explore how mass human migration affects the UHI. In this study, we investigate the role of mass human migration for the UHI during the CNY holiday in Harbin City for the period of 1992–2006 using observational data.

Table 3 Statistics of the UHI effects expressed as daily mean (ΔT_{mean}), maximum (ΔT_{max}), and minimum (ΔT_{min}) temperature differences between urban and rural stations averaged over the period of 1992–2006. The background period is defined as week −4 to week −1 and week +2 to week +5.

	UHI effect during the CNY week (°C)	UHI effect during the background period (°C)	Difference of UHI effect between the CNY week and the background period (°C)	Relative change of the UHI effect during the CNY week to the background period (%)
ΔT_{mean}	0.86	1.50	−0.65**	43
ΔT_{max}	0.34	0.65	−0.31*	48
ΔT_{min}	0.48	1.62	−1.14**	71

*Significant at the 98% confidence level by Student's *t*-test.
**Significant at the 99% confidence level by Student's *t*-test.

Our results indicate that the UHI effects during the CNY week are much lower than during the background period (four weeks before and four weeks after the CNY week). The reduction of ΔT_{mean} during the CNY week is 0.65°C, with respect to the background period. The reductions of ΔT_{max}, and ΔT_{min} are asymmetric, with magnitudes of 0.31°C and 1.14°C, respectively. The relative changes of ΔT_{mean}, ΔT_{max}, and ΔT_{min} to those during the background period are 43%, 48%, and 71%, respectively. These changes in ΔT_{mean} and ΔT_{min} are significant at the 99% confidence level by Student's *t*-test, and the ΔT_{max} change is significant at the 98% confidence level. The reduced population during the CNY holiday in the urban area of Harbin City leads to less human activities, which results in less anthropogenic heat emissions and also affects other processes, thus significantly reducing the UHI effects. Our findings provide observational evidence that mass human migration can significantly affect the UHI.

Acknowledgements. This work was supported by the National Natural Science Foundation of China (Grant Nos. 41275089 and 41305071) and the National Basic Research Program of China (Grant No. 2012CB955604). Jingyong ZHANG was supported by the Jiangsu Collaborative Innovation Center for Climate Change.

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