Nocturnal Warming of Urban Heat Island in Taipei Metropolitan Area

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Abstract

This investigation presents the nocturnal warming phenomenon from hourly temperature data of four station pairs in Taipei area during the 1964~2004 period. Analytical results show that the ascending rate of nocturnal warming of Taipei metropolitan area has been significantly rising in recent decades. This nocturnal warming is attributed to a strong negative Urban Heat Island (UHI) during the daytime (9:00am~16:00pm). In addition, the number of hours higher than 30℃ has been increasing at a rate of 2.5 hour/year during 18:00~24:00. The numbers of hours higher than 35°C in Taipei from 1964 ~ 2004 presents an obvious positive trend with a rate of 0.4 hour/year and indicates that the consistent warming tendency toward the future along with the global warming phenomenon.

Introduction

The nocturnal heat island results from diverging rates of cooling between the urban and the rural environments (Oke, 1982) and the thermal performance of an inner city is usually affected by land area, massing and surrounding buildings. UHI in Taipei metropolitan area was found in reaching a peak just two hours after sunset (about 8 p.m.), and its temperature distribution spreads in a nearly uniform pattern. These two features imply a serious development model for the Taipei metropolitan area. Also, Taiwan has been experiencing a regional scale heat-island effect and diurnal temperature has decreased by about 1.1 degrees since 1950, about twice the corresponding values over major continents. These changes induce significant impacts to air quality, heat stroke etc., and thus raise health risk concerns (Kalkstein and Smoyer, 1993). The effect of UHI in the subtropical Taipei city is showing an alarming signal (Liu, et al., 2002; Lin et al., 2005[a] and 2005[b]). In this study we chose fifteen CWB or EPA weather stations in Taipei metropolitan area, and selected four urban-rural pairs (Taipei-Wenshan, Taipei-Chuchi, Taipei-Shanchia, and Taipei-Shiji) for detailed comparison. “Center” means the average temperature and the geometric center of 15 stations (Table 1; Fig. 1).

Results and Discussion

Fig. 2(a) indicates a higher temperature spot in the center-left side and implies where the urban development started. Fig. 2(b) exhibits the 1 SD contours of

temperature variations. The most-uniform temperature distribution area implies the heaviest development section on the entire metropolitan area. Fig. 3 shows the daily average of UHI intensity for four station pairs mentioned above from 1998~2004. The monthly maximum UHI intensity in four pairs has an average value of 1.8 ^{o}C from 1998-2004. Fig. 4 illustrates the anomaly and linear trend of monthly mean maximum UHI for four pairs from 1998~2004. Fig. 5 shows the night-time at 18:00 to 24:00 from 1964~2004, with a rising rate of 2.5 hour/year. Apparently, the nocturnal warming is more evident than that of day-time trend at a factor of 2. Fig. 6 shows numbers of hours higher than 35^{o}C in Taipei from 1964 ~ 2004.

Conclusion

The warming trend in inevitable and a strategy to mitigate urban nocturnal warming is urgent and indispensable.

References

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Liu, SC., Lin, CY., Shiu, CJ**.**, Wang, CH., Liu, GR., Mega-suburb heat-island effect over Taiwan's western plain, *BAQ 16 Dec. 2002-18, Dec. 2002, Hong Kong SAR.*

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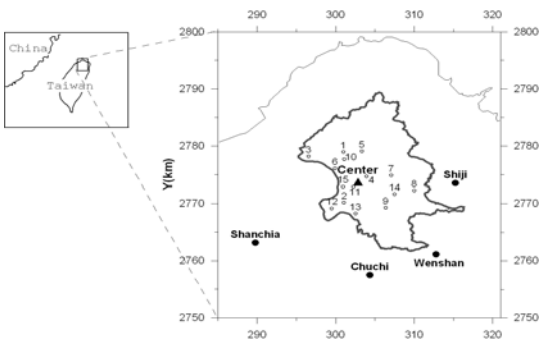


Fig. 1. Location map of Center and 15 stations (CWB or EPA) selected in Taipei, and Wenshabn, Chuchi, Shanchia, and Shiji are rural stations of this study.

Table 1. The related parameters of four rural stations of Taipei area.

Station Name	UHI (^{o}C)	H (m)	[a]D (km)	X (km)	Y (km)
Wenshan	1.68	410	16.0	312.8	2761.2
Chuchi	2.18	90	16.3	304.3	2757.5
Shanchia	1.60	10	16.9	289.8	2763.2
Shiji	1.72	15	12.4	315.3	2773.5

D: distance from rural station to "Center"; H: height

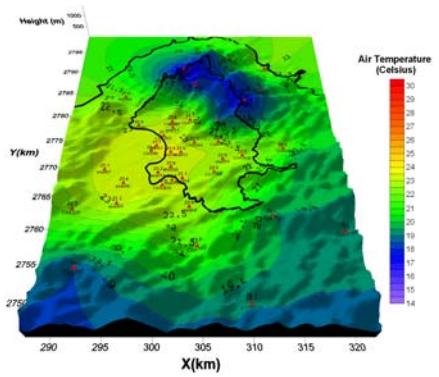


Fig. 2 (a) Temperature distribution in 8:00 p.m. from fifteen stations inside Taipei basin suggests a high temperature area (old downtown) in left side and implies where is beginning of the urban development was.

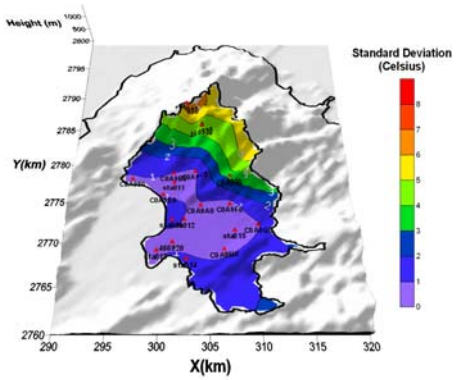
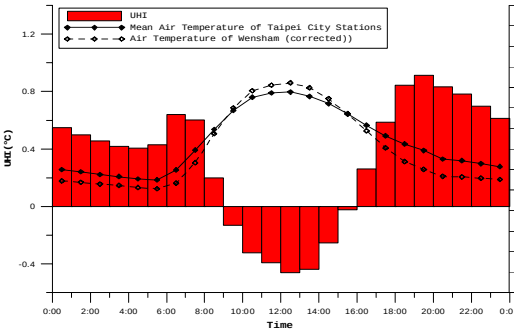
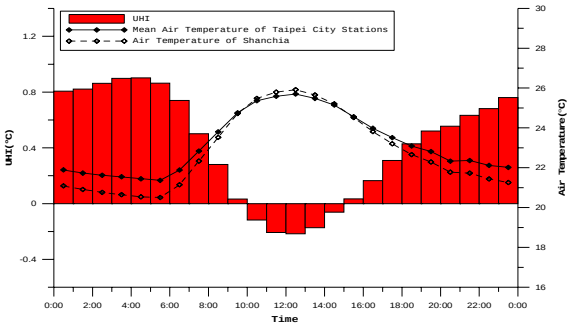


Fig. 2(b) The 1-SD (most-uniform) temperature distribution was marked as the purple color which indicates the densest development section in the entire Taipei basin.

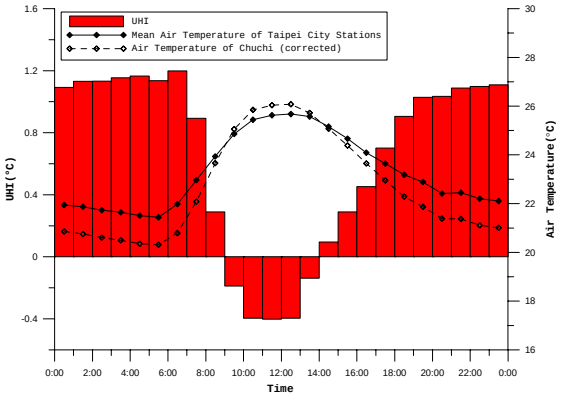
(a) Type 1：Taipei-WenShan



(b) Type 1：Taipei-Chuchi



(c) Type 1：Taipei-Shanchia



(d) Type 2：Taipei-Shiji

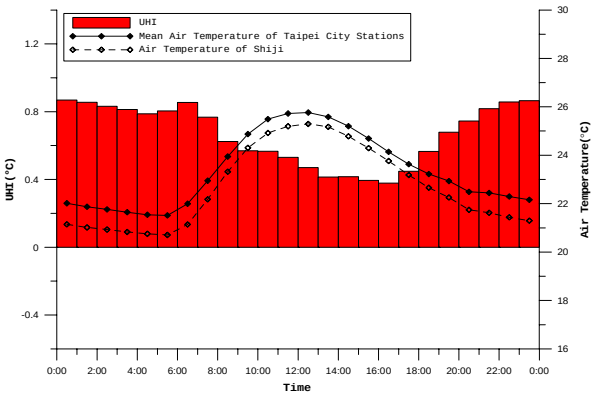
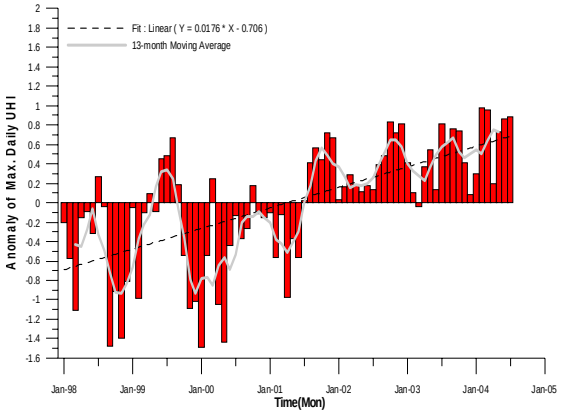
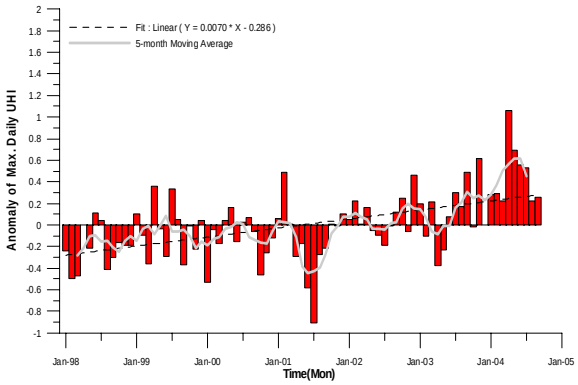


Fig. 3. Daily average of UHI intensity of four station pairs from 1998~2004. Red column shows UHI intensity. The UHI patterns of in type 1 and type 2 are quite different. The former displays negative UHI during the day-time, whereas the latter does not. This discrepancy means no significant temperature difference between city (Taipei) and rural (Shiji). This may be due to a rapid developing pace in Shiji during recent decades. Fig3(a) shows the peak of UHI intensity occurring at 2 hour after sunset and suggests the earlier reach of temperature climax is due to a relatively high urban density in city center. The fast ascending of UHI would induce a higher risk of temperature-related mortality.

(a) Type 1：Taipei-WenShan



(b) Type 1：Taipei-Chuchi



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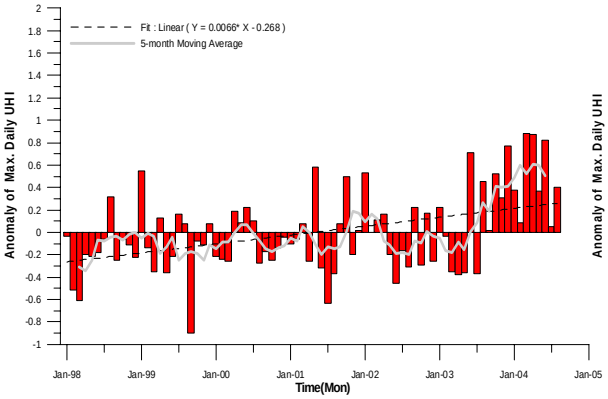

(d) Type 2：Taipei-Shiji

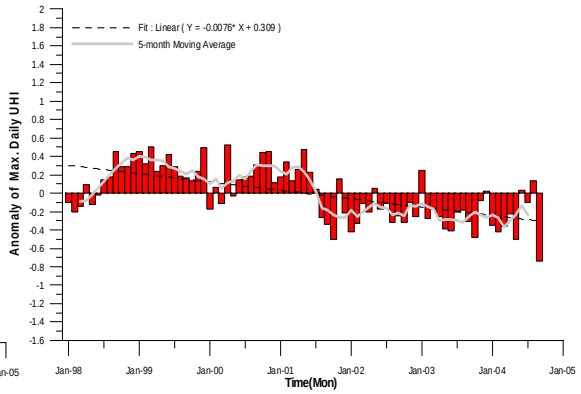

Fig.4. The anomalies and linear trends of monthly mean daily maximum UHI in four pairs of Taipei area in 1998~2004. Type 1 indicates an increasing trend with highest positive anomalies during the latest two years, whereas type 2 shows a decreasing tendency indicating an extensive development in recent years for Shiji area.

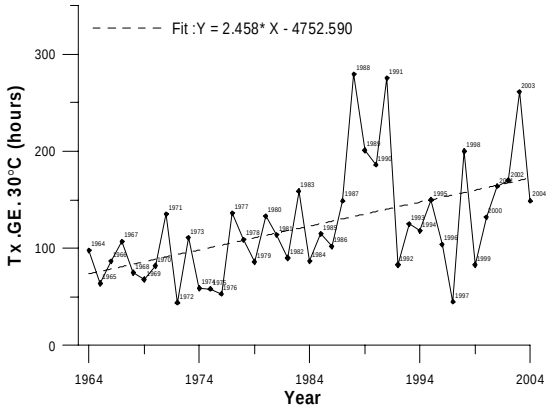

Fig. 5. The fast rising trend of number of temperature hours higher than or equal to 30 ^{o}C at 18:00 to 24:00 from 1964~2004 in Taipei.

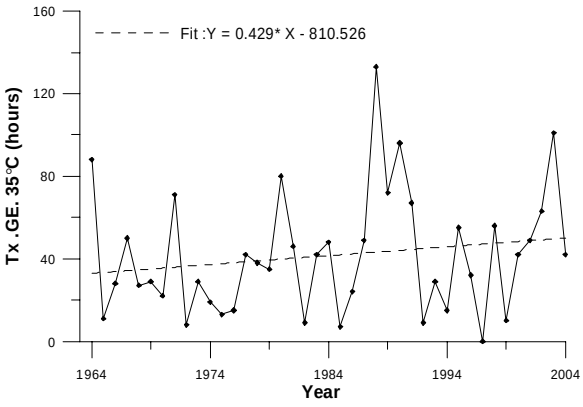

Fig. 6. The rising trend in number of temperature hours higher than or equal to 35 ^{o}C from 1964~2004 in Taipei.