香港天文台
HONG KONG OBSERVATORY

Reprint 1117

Urban Climate and Climate Change in Hong Kong

Hilda Lam

ASI 2011-2012: Urban Climatology for Tropical & Sub-Tropical Regions, School of Architecture, The Chinese University of Hong Kong, Hong Kong
5 December 2011

Urban Climate and Climate Change in Hong Kong

Hilda Lam
Hong Kong Observatory
hildalam@hko.gov.hk

Good morning,

It is my pleasure to be here to join this ASI programme on urban climatology for tropical and subtropical regions. In the next 10 minutes or so, I will summarize the work of the Observatory on climate change and urban climate in Hong Kong. Since the mid 19th century, Hong Kong has transformed from a fishing village into a modern metropolis with 7 million people, many high rise buildings and hundreds of thousands of cars. The environment of the territory has changed a lot and so is that around the Observatory which is located in urban Kowloon (Figure 1). It is at this spot that the Observatory has been making weather observations for over 125 years, providing valuable data (from 1885 except for the period between 1940 and 1946) for studying climate, climate change and the effect of urbanization. To highlight the effects of urbanization, the Observatory also makes use of measurements at rural sites which are less affected by urban development. Examples are Ta Kwu Ling which is in the country side in the northern part of the territory and Waglan Island which is an uninhabited island in the southeastern part of Hong Kong (Figure 2).

Based on the long-term observation at the Hong Kong Observatory in urban Kowloon, a number of changes in local climate are observed.

a) First of all, Hong Kong is getting warmer, like the rest of the world but the rate is faster than the global trend (Figure 3). The long term rise in temperature is 0.12 deg per decade, and the rate of rise has also been increasing in recent decades. Around 50% of the warming is estimated to be due to urbanization (Chan et al., 2012);
b) secondly, there is a long term rise in annual rainfall of 24mm per decade (Figure 4). Although the annual rainfall is increasing, the number of rain days

is decreasing (Figure 5), suggesting that Hong Kong does not rain as often as before but once it rains, the rain is heavier than in the past ; and

c) thirdly, extremely cold events have become rarer and extremely hot events become more common; heavy rain events become more often (Figure 6). This is also supported by the more and more frequent breaking of the record of maximum hourly rainfall at the Observatory (Figure 7). The record hourly rainfall used to increase by about 10 to 20 mm in some 40 years. However, it shot up to 145mm in 2008. The jump in the maximum hourly rainfall has raised concern to emergency response personnel and engineers responsible for flood control and drain design.

These trends are expected to continue into the future, in accordance with our climate projection based on the IPCC AR4 model output. Temperature is expected to continue to rise by about 3 to 7 degrees by the end of the century (Figure 8). The number of cold days would decrease and the number of hot nights and hot days would rise by 8 to 10 folds (Figure 9). The rainfall projection (Figure 10) is characterized by large uncertainty and rainfall is expected to rise by about 10% in the latter half of the 21st century.

Besides global warming, urbanization also contributes to climate change observed in Hong Kong. The time plot of the number of hot nights (Figure 11) shows significant rise from the 70's onwards rising from about 5 to over 20 nights in recent years. The increase in hot night is known to be related to the built-up of urban area as the concrete in buildings absorbs heat during the day, releasing them at night. With more hot nights, we find it increasingly difficult not to turn on the air conditioner when we sleep in the summer. For the underprivileged, it would be even more unbearable.

Visibility reduction is linked to urbanization. The visibility time plot (Figure 12) shows quite a dramatic increase in the hours of visibility below 8km now than back in the 70's and 80's. Visibility reduction is likely due to the increase in suspended particulates due to industrialization and urbanization. Part of the particulates may come from outside Hong Kong. However, local sources cannot be ruled out with the increase in energy use and more vehicles around.

The mean cloud amount (Figure 13) shows an increasing trend in the past 50 years or so which is a likely effect of urbanization. The increased level of suspended

particulates raises the concentration of condensation nuclei in the air, favouring the formation of cloud and is known to be associated with urbanization and human activities in the region. With more and more suspended particulates in the air and more cloud in the sky, the amount of solar radiation received on the ground would be affected. Indeed we have observed that the amount of solar radiation measured in Hong Kong shows a decreasing trend (Figure 14). It should be noted that the decrease in solar radiation has suppressed global warming effect during day time.

To study the characteristics of urbanization more closely, we compare the measurements at urban and rural sites (Figure 15). With warmer nights and less solar radiation during day time, we can see that the temperature at the Observatory has a smaller diurnal range than that at Ta Kwu Ling. If we define the difference in temperature between the two sites to be the UHI effect, it is observed that the UHI is most prominent in early morning in winter (Figure 16). The rainfall difference between urban and rural regions is also found to be on an increasing trend by about 2.7mm per year (Figure 17). This may indicate that urbanization could enhance rainfall. The urban buildup is expected to cause wind speed to decrease as the buildings increase surface roughness and thus enhancing the drag on the surface winds. It is observed in Hong Kong that while there is no significant trend in the wind speed at Waglan Island (Figure 18), the wind speed measured in urban Kowloon shows a long term decreasing trend.

To summarize, besides global warming, local urbanization also contribute partly to the observed changes in the climate of Hong Kong over the past century, including the long term increase in average temperature, reduction in visibility, increase in cloud amount, decrease in solar radiation and reduction in wind speeds in urban areas (Figure 19). With global warming and urbanization, conditions in the city could be deteriorating in terms of human health and comfort, particularly in hot stuffy summer nights. All of us, government, building and engineering sectors and individuals should work together to mitigate the adverse effects of global warming and urbanization so that our city would be livable not only for now but also for future generations.

References

Hong Kong Observatory, 2011: Climate Change in Hong Kong, published by the Hong Kong Government.

Chan H.S., M.H. Kok & T.C. Lee, 2012: Temperature trends in Hong Kong from a seasonal perspective, Climate Research 55:53-63 (2012) - doi:10.3354/cr01133, HKO Reprint No. 1042 (November 2012)

Ginn W.L., T.C. Lee, and K.Y. Chan, 2010: Past and future changes in the climate of Hong Kong. Acta Meteor. Sinica, 24(2), 163-175.

Lee, T.C., K.Y. Chan & W.L. Ginn,2011: Projection of extreme temperatures in Hong Kong in the 21st century, Acta Meteorologica Sinica, 25(1), 1–20.

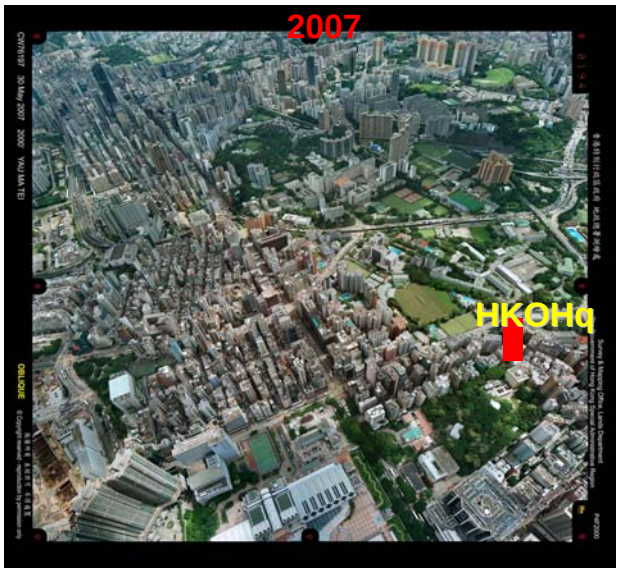
Leung Y.K., K.H. Yeung, E.W.L. Ginn & W.M. Leung, 2004: Climate Change in Hong Kong, HKO Technical Notes 107, (February 2004)

Mok, H. Y., Y. K. Leung, T. C. Lee, and M. C. Wu, 2006: Regional rainfall characteristics of Hong Kong over the past 50 years. Conference on “Changing Geography in a Diversified World", Hong Kong Baptist University, Hong Kong, China, 1-3 June 2006. Hong Kong Observatory Reprint No. 646.

Wong, M. C., and H. Y. Mok, 2009: Trends in Hong Kong climate parameters relevant to engineering design. HKIE Civil Division Conference 2009: Conference on Engineers' Responses to Climate Change. Hong Kong Observatory Reprint No. 832.

Wu, M.C., Y. K. Leung, W. M. Lui, and T. C. Lee, 2008:A study on the difference between urban and rural climate in Hong Kong. 22nd Guangdong-Hong Kong-Macau Seminar on Meteorological Science and Technology, Zhongshan, China, 21-23 January 2008. Hong Kong Observatory Reprint No. 745.

(a) 1908



(b) 2007 (Source: Lands Department)

Figure 1. Rapid urban development around the Hong Kong Observatory Headquarters

(a) Hong Kong Observatory Hq (urban Kowloon) - Weather observations since 1884, except during WW II

(b) King's Park Meteorological Station (urban Kowloon) - Climate and upper-air station since 1951

(c) Ta Kwu Ling Automatic Weather Station - Rural weather station in Hong Kong since 1985

(d) Waglan Island (uninhabited off-shore island) - Weather monitoring since 1952; automatic station from 1989.

Figure 2. Stations monitoring the climate in Hong Kong

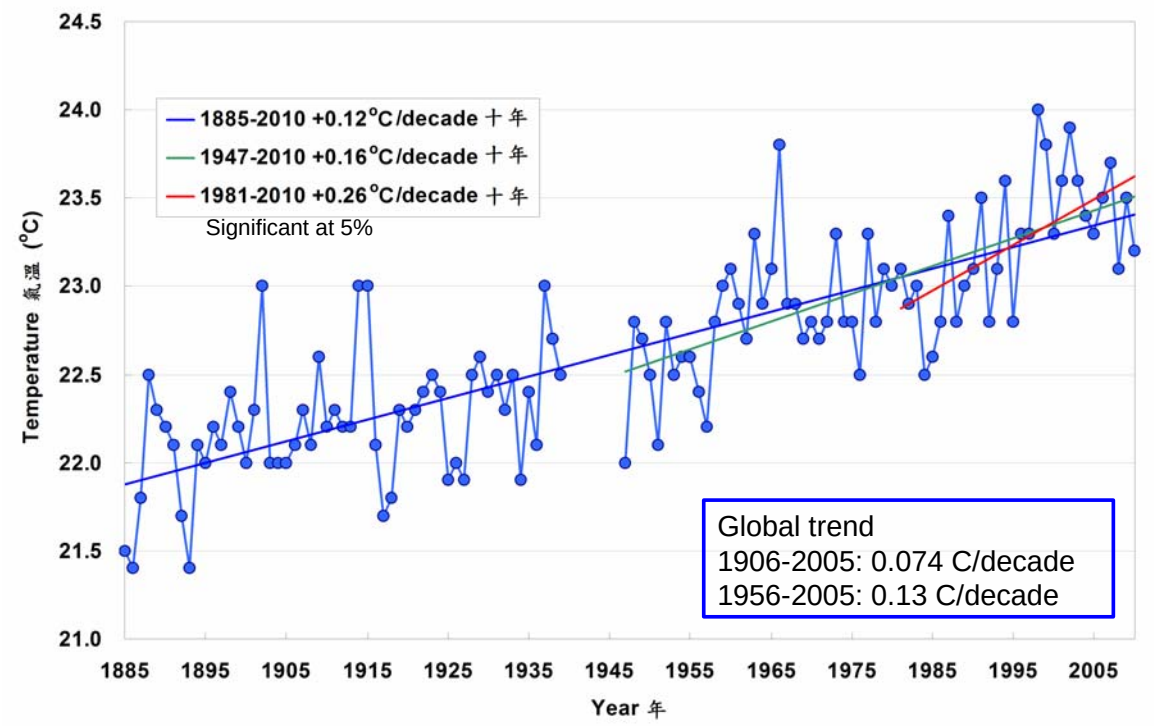


Figure 3. Rising annual temperature in Hong Kong (1885-2010), ~50% of warming due to urbanization

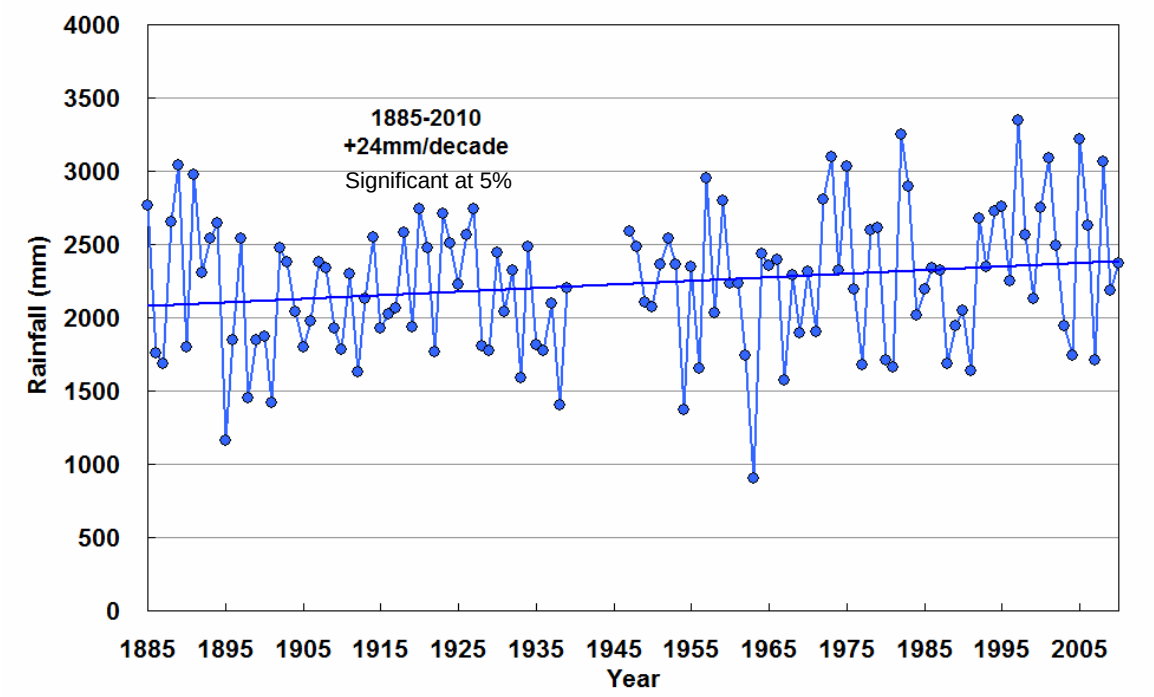


Figure 4. Rising annual rainfall in Hong Kong (1885-2010)

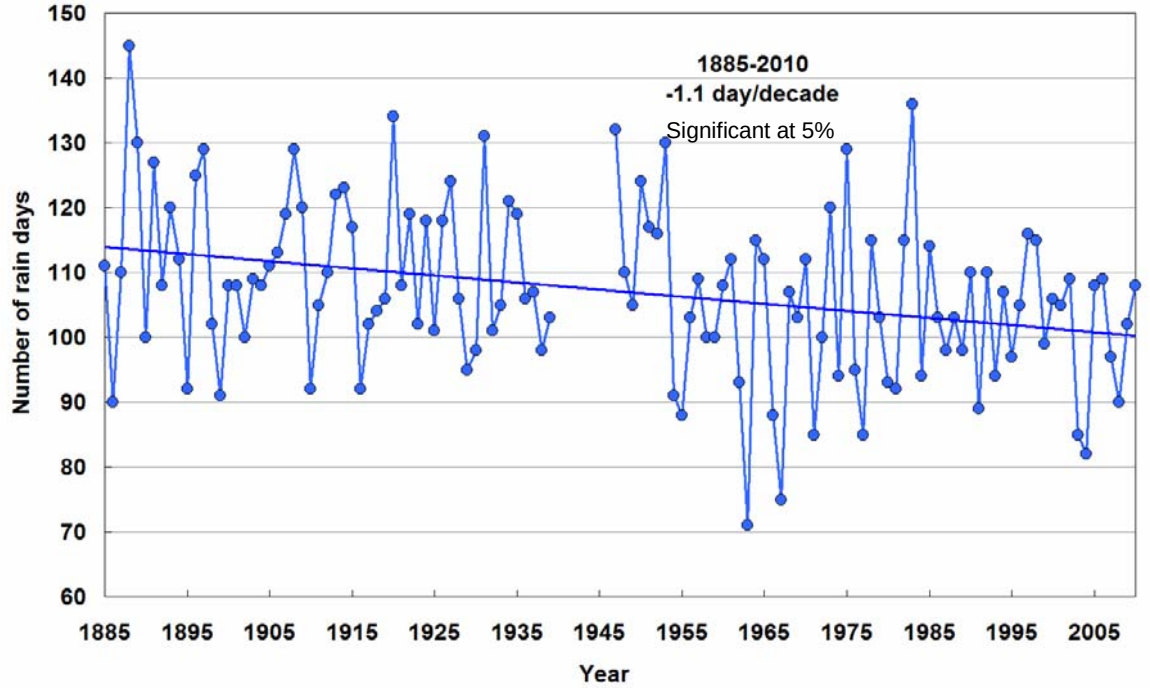


Figure 5. Decreasing number of rain days (daily rainfall >=1 mm)

Extreme event	Return period in 1900	Return period in 2000
Minimum Temp. $\leq 4^{\circ}C$	6 years	163 years
Maximum Temp. $\geq 35^{\circ}C$	32 years	4.5 years
Hourly rainfall $\geq$ 100mm	37 years	18 years
2-hourly rainfall $\geq$ 150mm	32 years	14 years
3-hourly rainfall $\geq$ 200mm	41 years	21 years

Figure 6. Analysis using time dependent Generalized Extreme Value (GEV) distribution (from Wong and Mok, 2009)

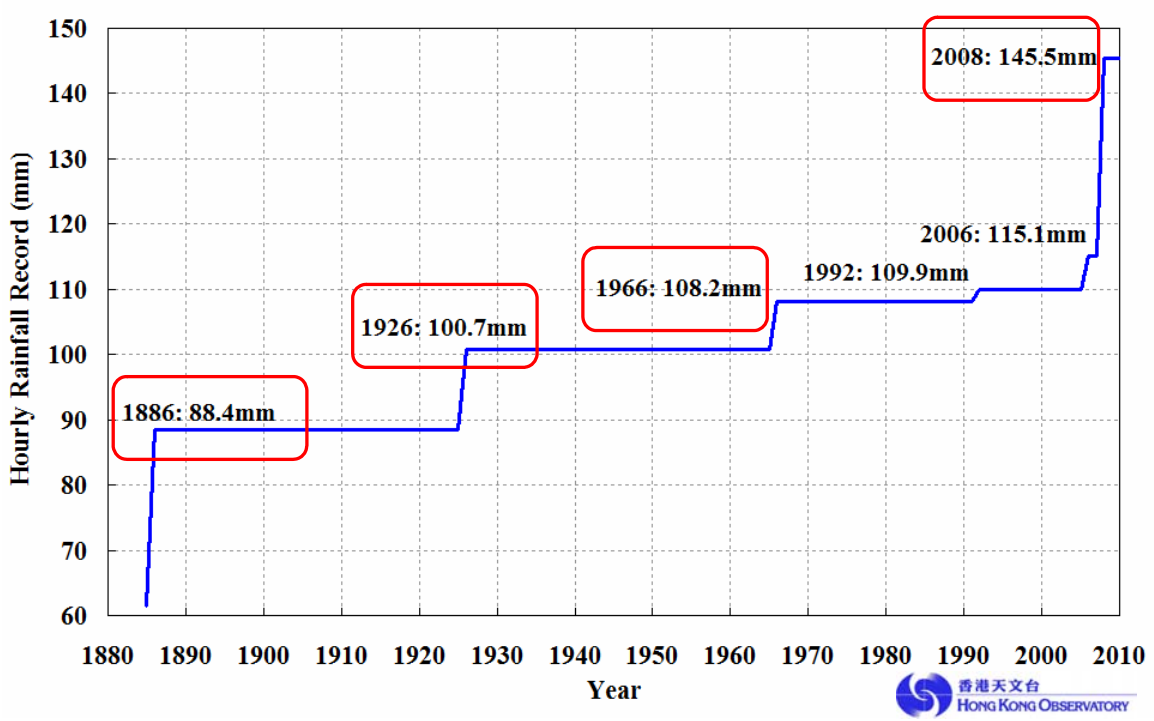


Figure 7. Record high hourly rainfall at the HKO (1885 – 2010)

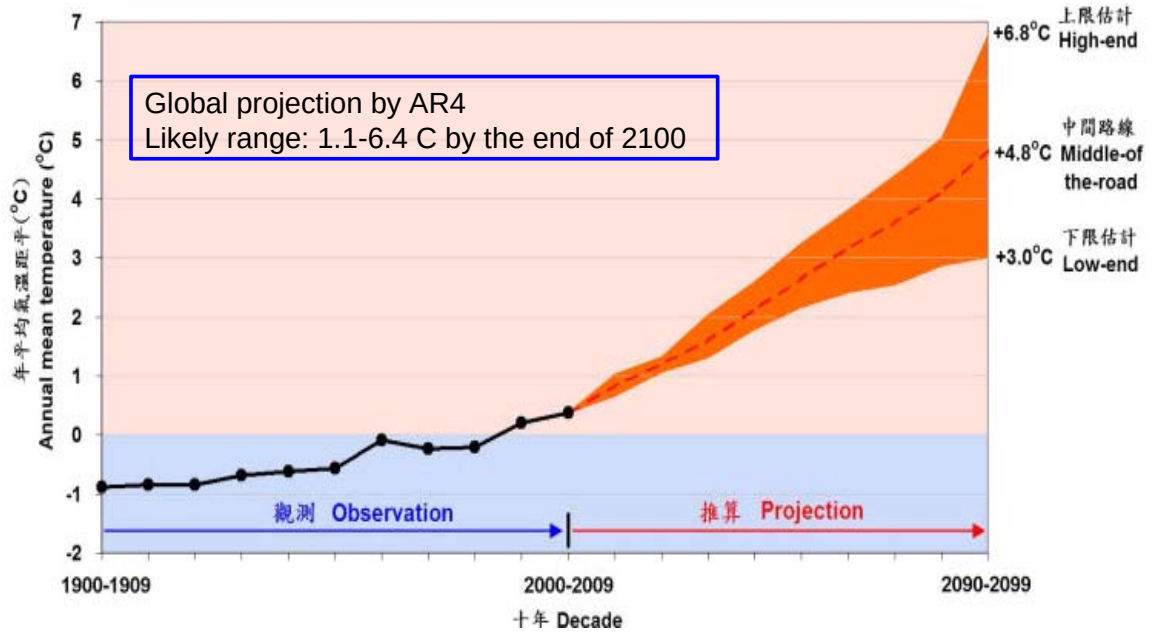


Figure 8. Temperature projection for Hong Kong (HKO, 2011)

	1980-1999 (actual)	2050-2059	2090-2099
Annual no. of cold days (Tmin<=12C)	17	4	1
TN10p (%)	9.4	1	0.3
TN90p (%)	11.6	53.4	74.2
Annual no. of hot nights (Tmin>=28C)	16	96	137
Annual no. of very hot days (Tmax>=33C)	9	51	89

Figure 9. Projection of extreme indices in Hong Kong (From Lee et al., 2011)

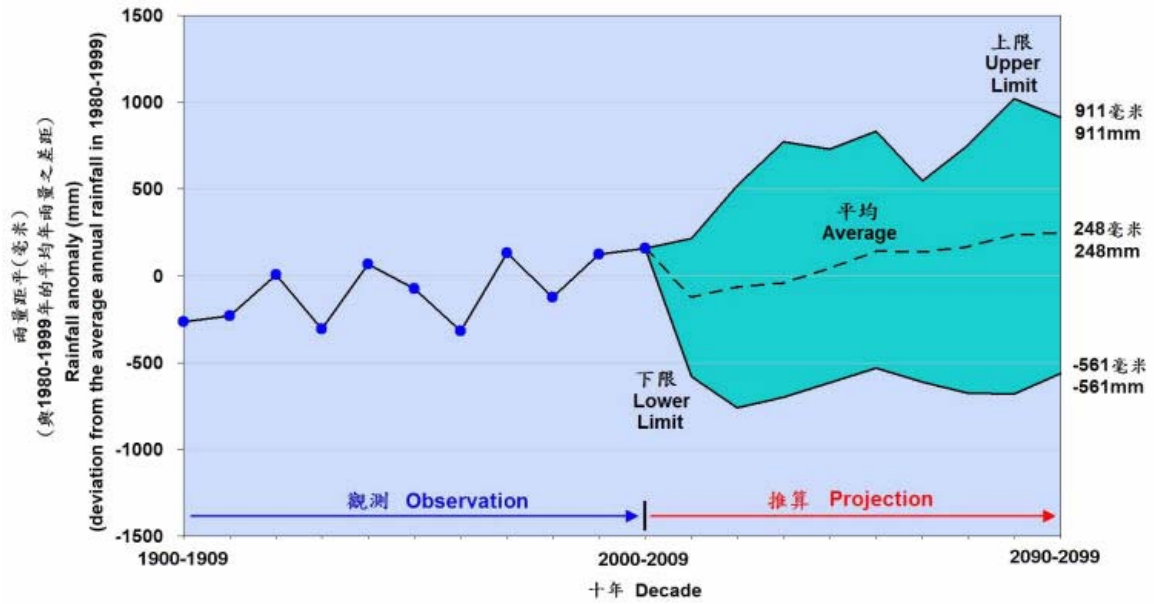


Figure 10. Rainfall projection for Hong Kong (HKO, 2011)

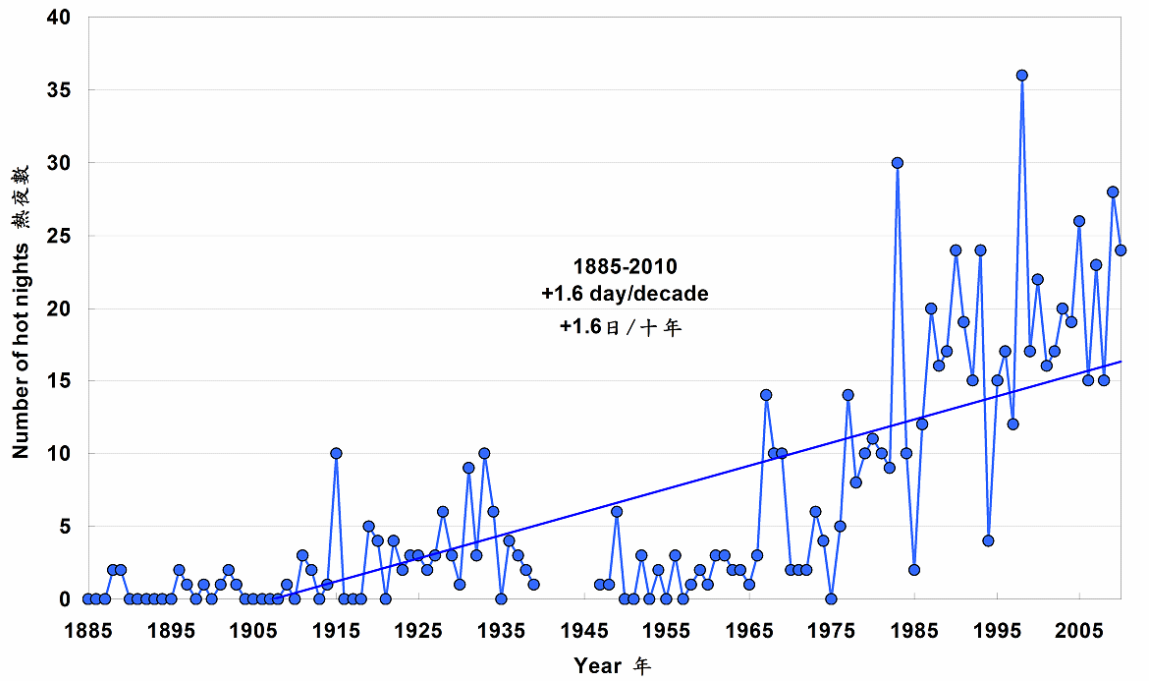


Figure 11. Annual number of hot nights in Hong Kong (1885-2010) (Daily Min. Temp >= 28°C)

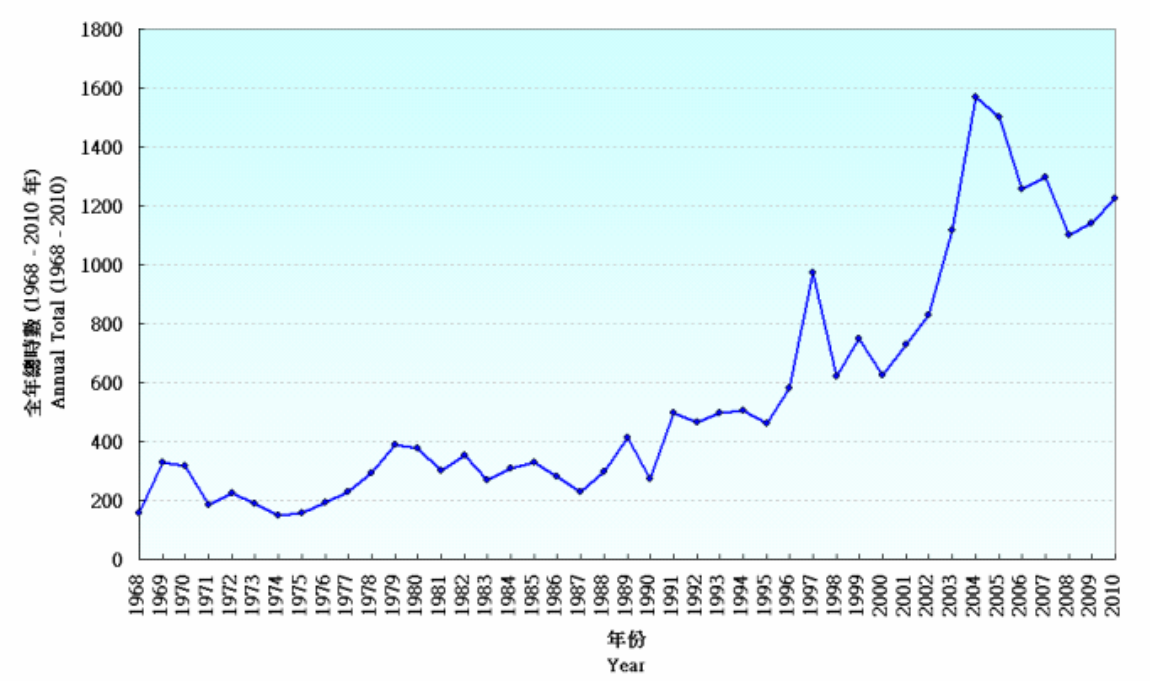


Figure 12. Annual total number of hours with visibility at HKO Headquarters below 8km from 1968-2010 (relative humidity below 95% and not counting rain, mist or fog)

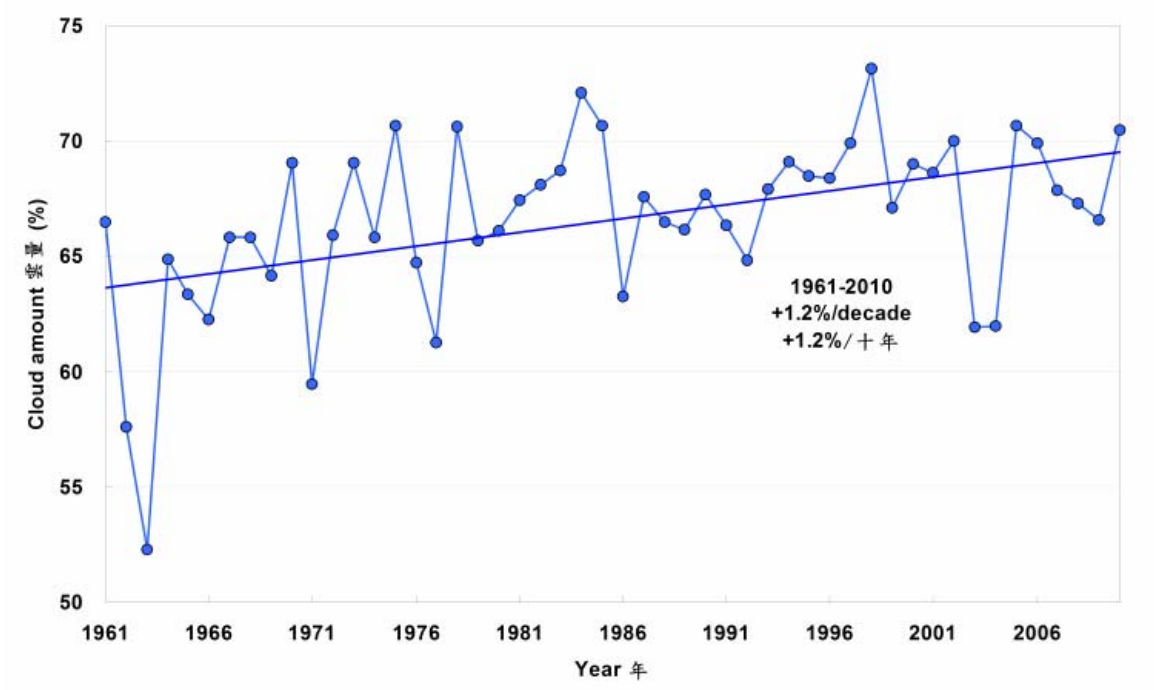


Figure 13. Annual mean cloud amount recorded at the Hong Kong Observatory Headquarters (1961-2010)

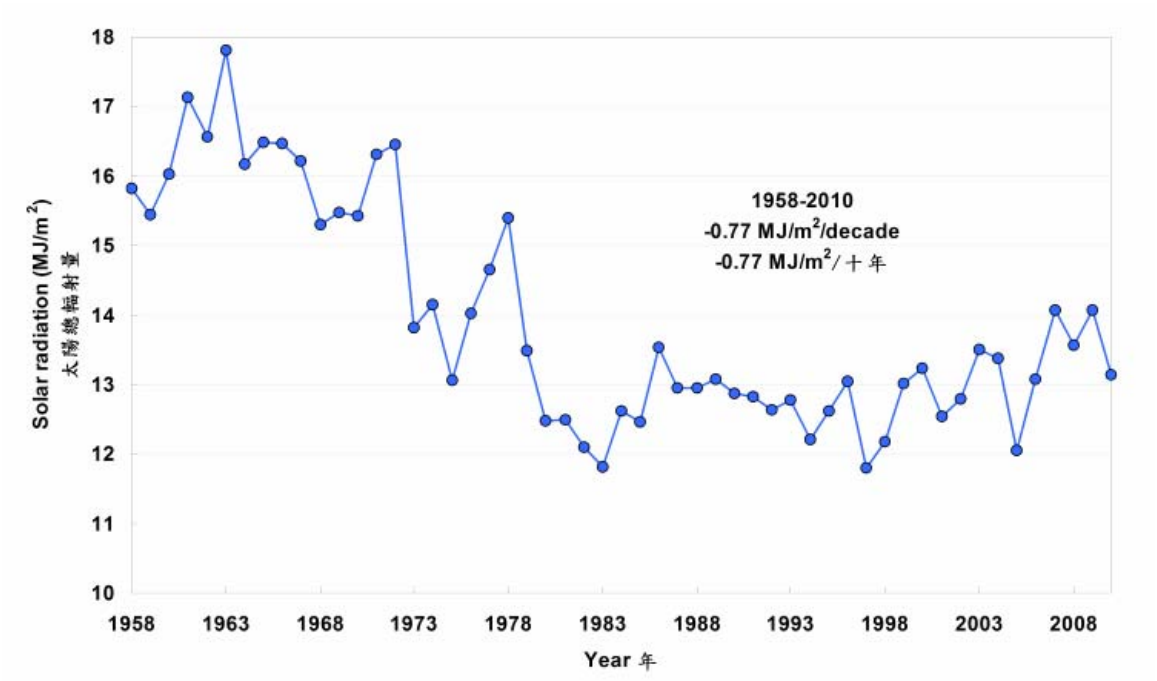


Figure 14. Annual mean daily total global solar radiation at King's Park (1958-2010)

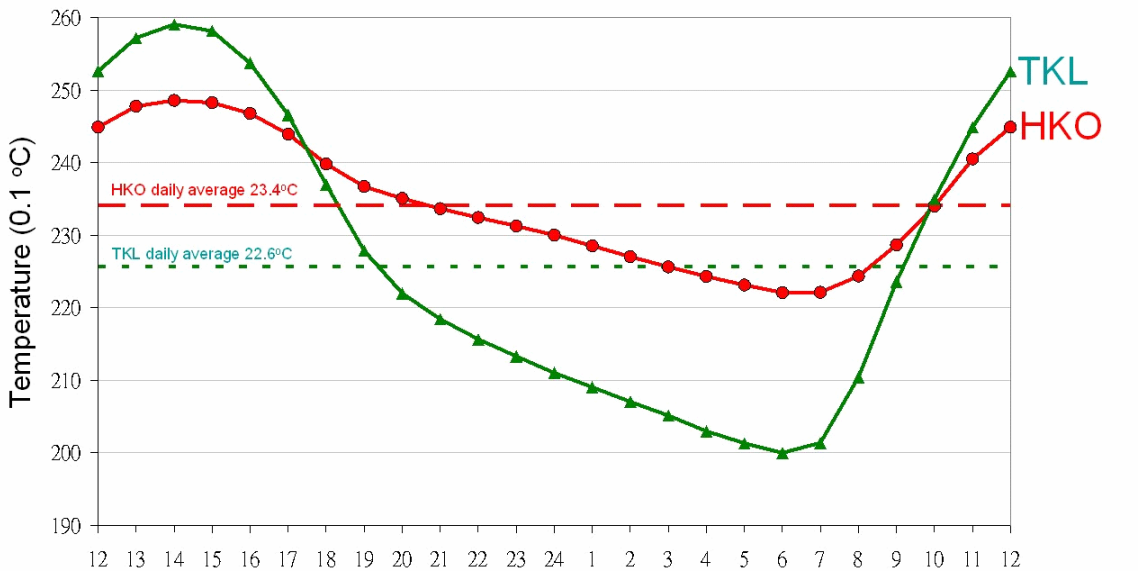


Figure 15. Characteristics of Urban Heat Island Effect in Hong Kong HKOHq vs Ta Kwu Ling (TKL). Diurnal variations of the average of HKO and Ta Kwu Ling (TKL) temperatures from 1989 to 2007 (From Wu et al., 2008).

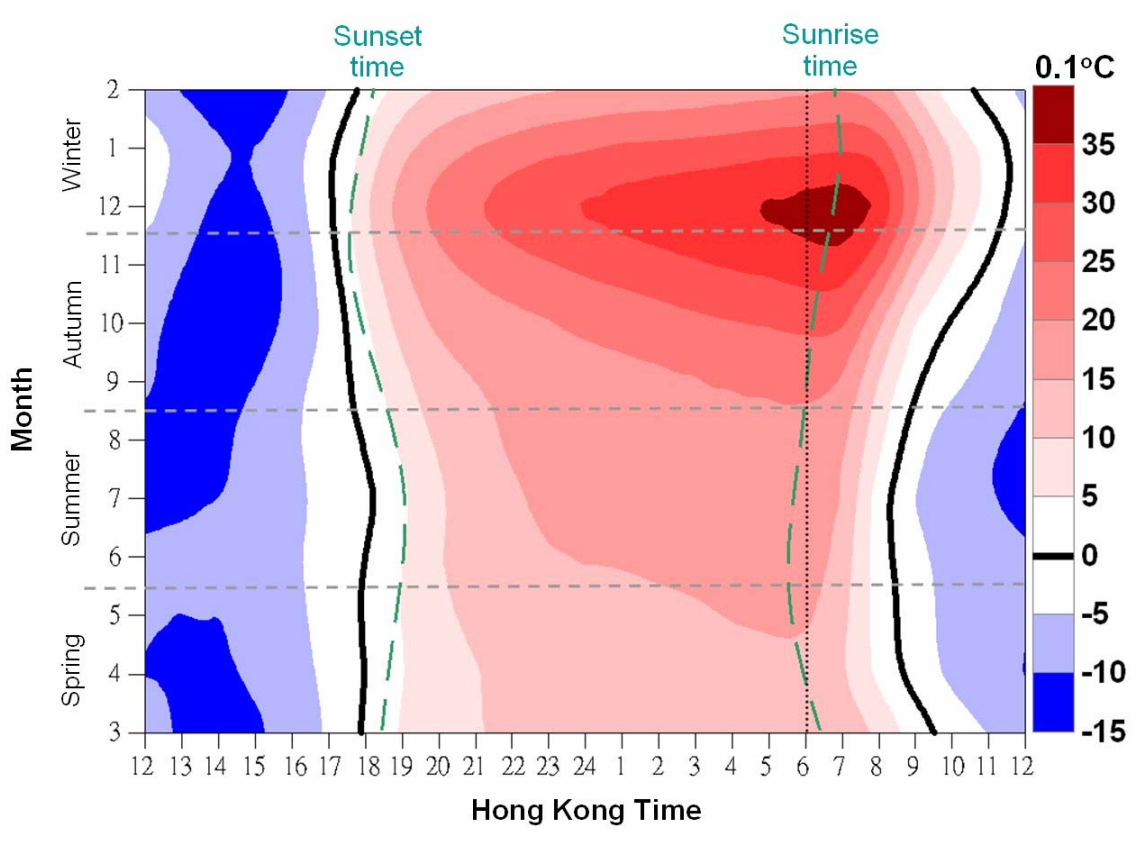


Figure 16. Seasonal variations in the UHI intensity
Diurnal variations of average Tu-r of Hong Kong in different months (1989-2007). Tu-r = Tu – Tr, where Tu and Tr are respectively the air temperature of HKO and TKL. (From Wu et al., 2008)

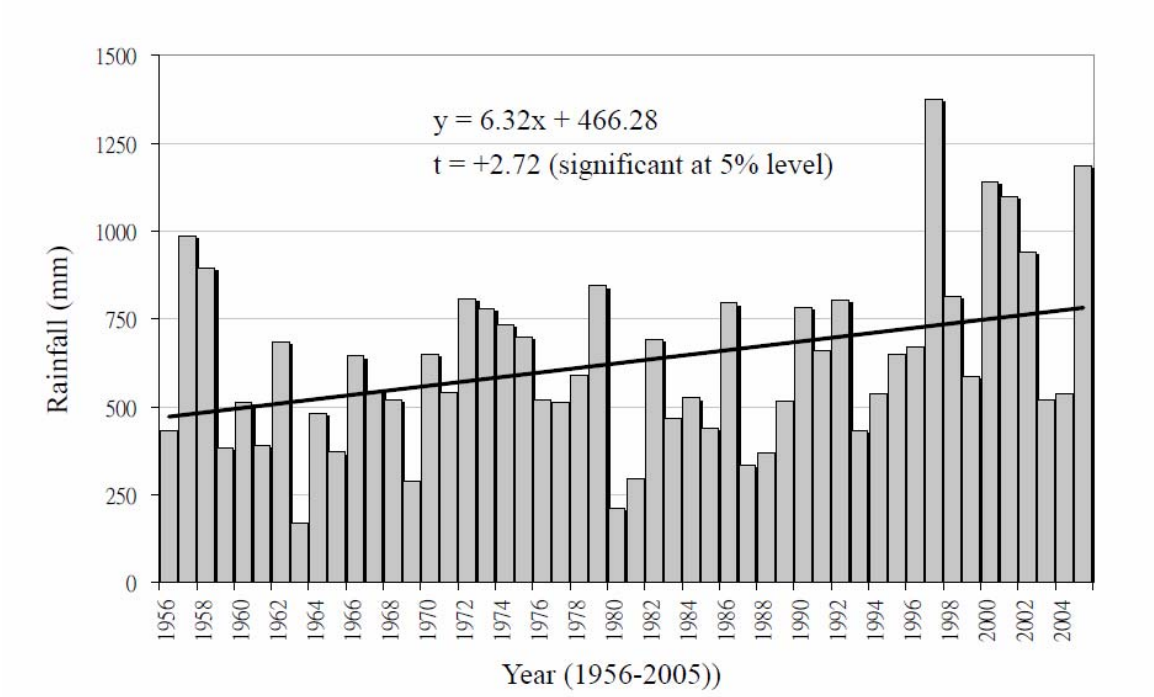


Figure 17. Time series showing the annual rainfall difference between the Urban region and Offshore region (Urban minus Offshore). The solid line indicates the linear trend over the period between 1956 and 2005. The rainfall over different regions of Hong Kong was generally on a rising trend. The rate was higher over the urban areas than the New Territories, offshore islands and high grounds. Urbanization is one of the possible causes for the rainfall's increasing trend and the regional variation in Hong Kong. (From Mok et al., 2006)

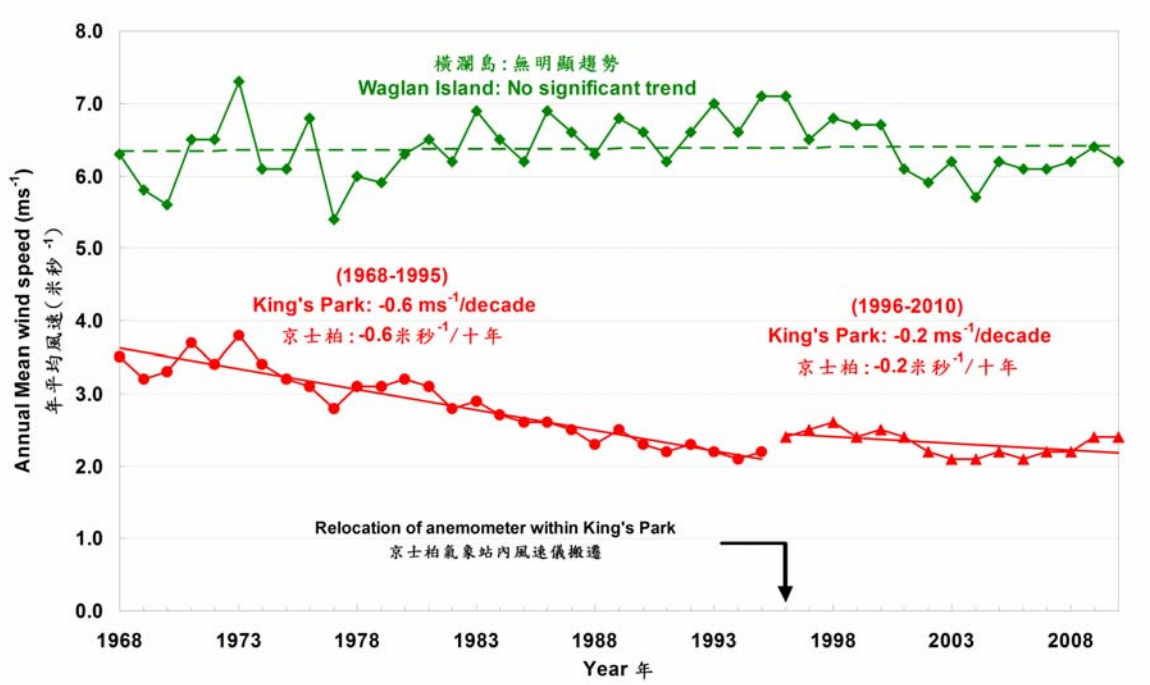


Figure 18. Annual average of 12-hr 10 minute mean wind speed at King's Park and Waglan Island (1968-2010)

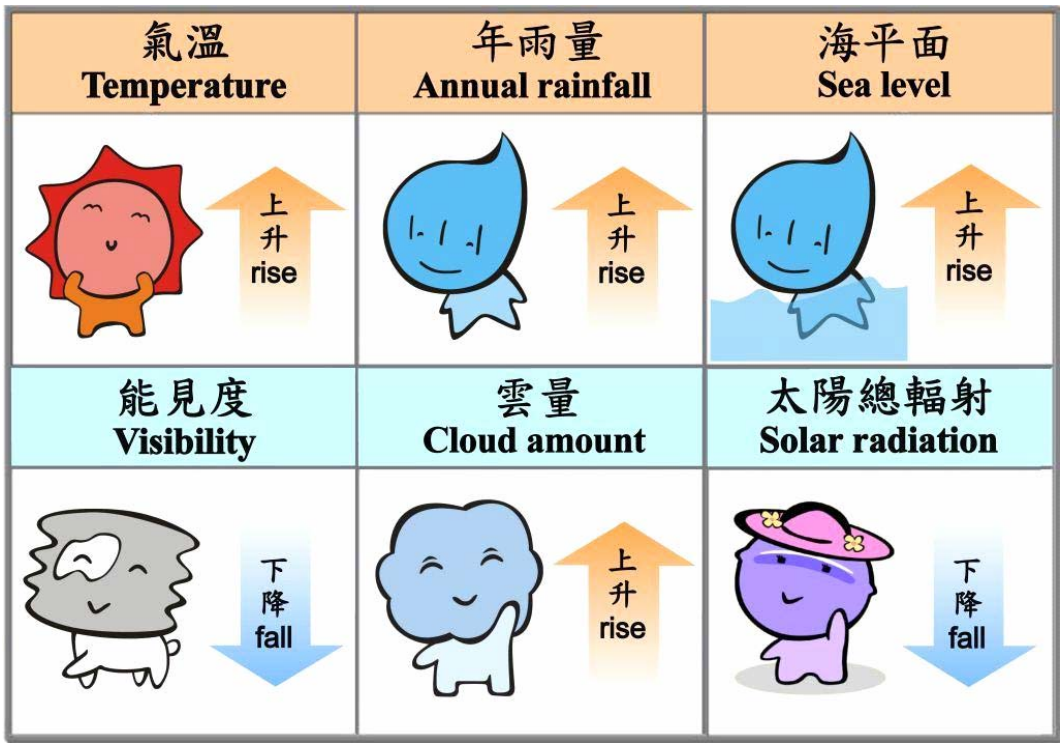


Figure 19. Observed climate change in Hong Kong Over the last century (HKO, 2011)