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On Climate Changes Brought About by Urban Living

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# On Climate Changes Brought About by Urban Living

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## 1. Introduction

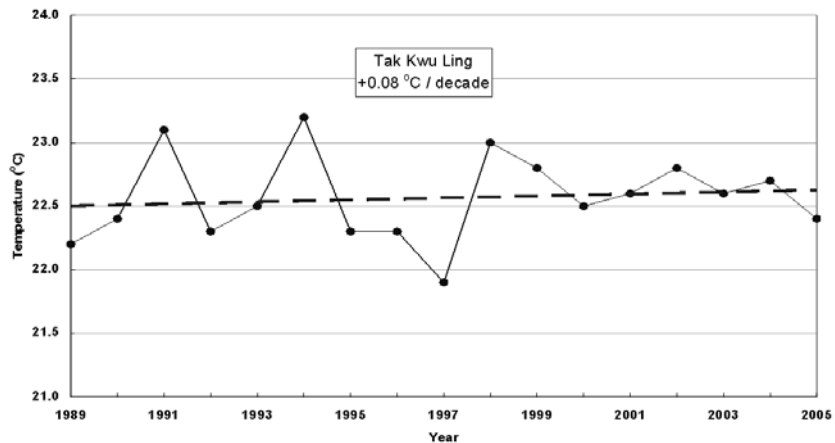
Hong Kong went through a period of major urbanization in the past half century. Much more land than before is now under concrete. Clusters of tall buildings have invaded into previously open country. At the same time, the increase in population as well as per capita energy consumption in this affluent society have meant the burning of much more coal and petrol than before, with the attendant emissions of gases and particulates. The atmosphere overlying Hong Kong cannot escape interacting with these changes. In the process of doing so, the climate in Hong Kong has changed. Leung et al. (2004) have documented the long-term changes in various observed parameters up to 2002. This paper extends the data series to 2005 and also looks at a couple of aspects not covered before.

## 2. Temperature

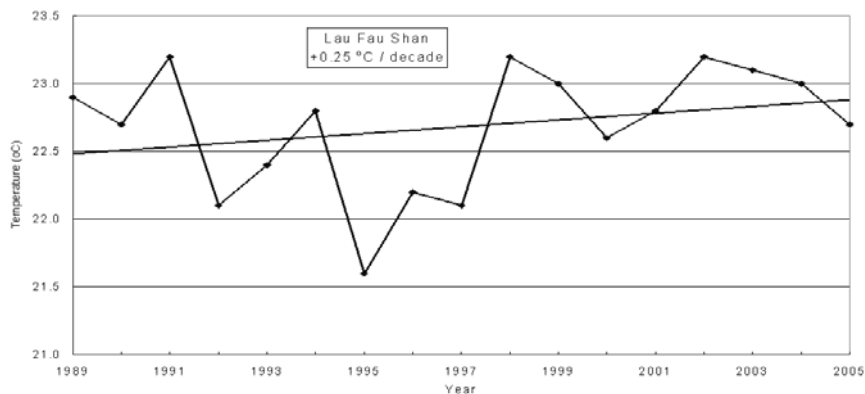
The aspect of change in Hong Kong which is most obvious to all is the generally warmer climate in the urban areas. Figure C4 shows the time series of the annual mean temperature recorded at the headquarters of the Hong Kong Observatory between 1947 and 2005. The Observatory is situated at the heart of Tsimshatsui and is characteristic of a location where urbanization is at its most active in Hong Kong over the past half century. Over the entire period, the temperature rose at  $0.17^{\circ}\text{C}$  per decade. However towards the end of the period, between 1989 and 2005, the rate increased sharply to  $0.37^{\circ}\text{C}$  per decade.

In order to contrast with stations in locations less affected by urbanization, the temperature series at Ta Kwu Ling and Lau Fau Shan which are situated in the northeastern and northwestern New Territories respectively are shown in Figure 1. The rates of temperature rise at these two stations over the same period 1989 – 2005 were  $0.08$  and  $0.25^{\circ}\text{C}$  per decade respectively. That the urban area has been warming up much more rapidly than the “countryside” is thus evident.

It is well-established that where urbanization bears on the long-term temperature trend, the effect is more on the daily minimum temperature than on the daily maximum temperature (Karl et al., 1993). This is related to the increase in the thermal capacity of the urban area where concrete stores the heat absorbed during the day and releases it during the night, thus holding the temperature at a level higher than it would be in the absence of so much concrete. Figure C5 portrays the trends in mean daily maximum and minimum temperature at the headquarters of the Hong Kong Observatory over the period 1947 – 2005, that is, the post-war development years. The trend in daily maximum temperature was nearly flat, the influence of general global warming having been overshadowed by the increasingly turbid sky (a point which we shall return to later). In contrast, the mean daily minimum temperature has been rising steadily throughout the period, at a rate of  $0.28^{\circ}\text{C}$  per decade. The signature of urbanization in the temperature trend is thus abundantly clear.



**Figure 1(a). Annual mean temperature recorded at Ta Kwu Ling (1989-2005).**



**Figure 1(b). Annual mean temperature recorded at Lau Fau Shan (1989-2005).**

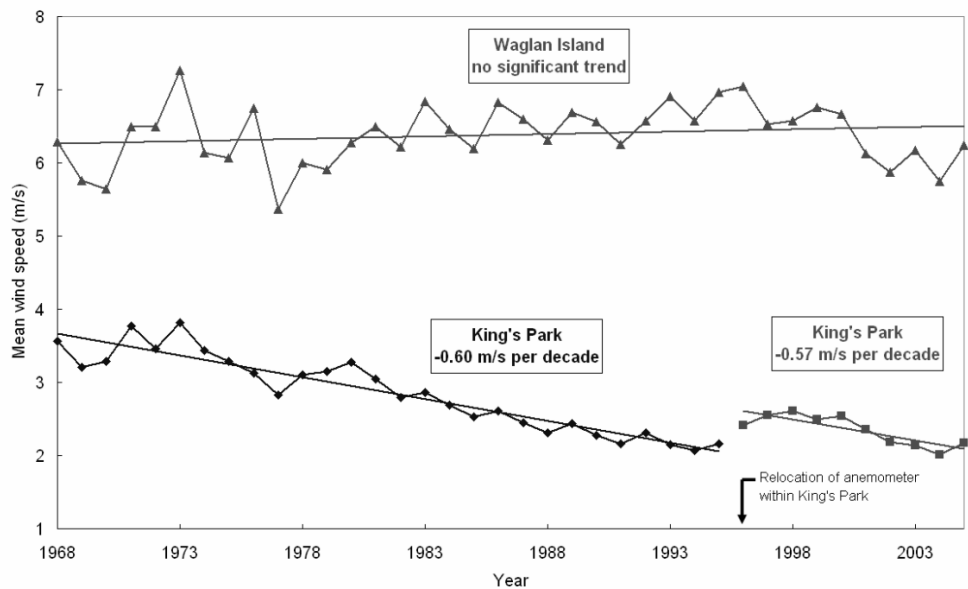
### 3. Wind

Another hallmark of urbanization is the growing number of buildings. It increases the roughness of the surface underlying the atmosphere and exerts a drag on the low-level winds. The tendency therefore is to see wind speed near the ground decreasing in the long run. Figure 2 shows the time series of wind speed measured at King’s Park and Waglan Island in 1968 – 2005. For technical reasons and in order to compare like with like, the data points represent the annual average of 10-minute wind speed readings taken twice daily, at 8 a.m. and 8 p.m.

Waglan Island is an offshore location and so the observations there reflect purely the background climate without the impact of urbanization. There was no significant long-term trend in the wind speed there. However, at King’s Park which is situated on a knoll surrounded by Yaumatei, Mongkok, Homantin and, slightly further afield, Hunghom, there has been a steady decrease in the wind speed.

Because the anemometer at King’s Park meteorological station was re-located (within the station) in 1996, two segments of the time series are shown in the figure. But the sustained decrease in wind

speed remains evident. By contrasting the two time series, it is clear that urbanization in the broad



**Figure 2. Annual average of 12-hourly 10-minute mean wind speed of King's Park and Waglan Island (1968-2005).**

vicinity of King's Park has brought down the wind speed in the boundary layer of the atmosphere around the station. The urban area is therefore generally less well ventilated than before.

#### 4. State of Sky

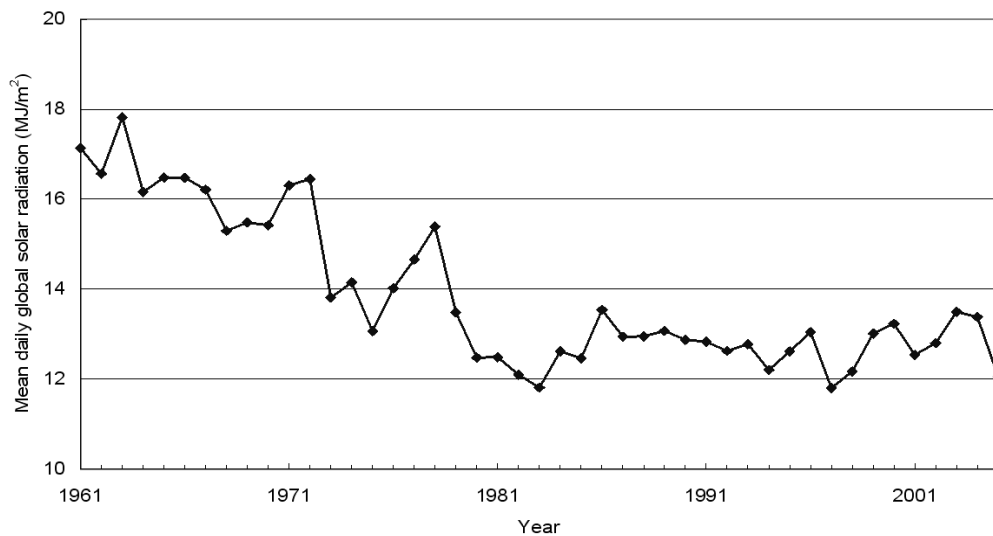
One visible aspect of climate change is the turbidity in the sky which more and more local people are concerned about. It is caused by suspended particulates of one kind or another thrown up by human activities in the city. It may be purely dust and natural (e.g. loess from northern China). It could also be particulates formed from combustion products (e.g. vehicle exhaust, kitchens and power generation) through photochemical processes. Figure C6 shows the time series of the annual total number of hours with visibility at the Hong Kong Observatory headquarters below 8 km from 1968 to 2005. Cases of reduced visibility due to rain or mist or associated with high relative humidity are excluded, because those would be more like "natural" weather.

Up to the late 1980s there was no significant trend. But from then onwards, there has been a dramatic rise in the frequency of reduced visibility. By 2005, the frequency was five times that in the seventies and the eighties. It could be argued that some of this increased turbidity of the atmosphere is transported to Hong Kong from outside. But, considering the large consumption of energy within Hong Kong itself, which invariably involves combustion of one form or another with its attendant emissions, there is no question that some of this turbidity is locally generated by the urban form of living practised here.

Leung et al. (2004) also reported that the annual mean cloud amount observed at the Hong Kong Observatory headquarters has been increasing at a rate of 1.8% per decade in the period 1961 – 2002. One potential cause could be the increase in the concentration of condensation nuclei in the air (a

factor favourable to the formation of cloud), which is known to be associated with urbanization.

Increased turbidity and increased cloud amount reduce the amount of solar radiation reaching the ground. Figure 3 shows the time series of the annual mean of the daily amount of solar radiation measured at King's Park between 1961 and 2005. There has been a clear, broad falling trend. With the lesser amount of solar energy reaching the ground, the urban heat island effect during the day has therefore been suppressed. This provides the context for us to view the nearly flat trend in the daily maximum temperature in Figure C5. It also prompts us to think what the consequences might be in terms of reduced illumination in buildings and reduced ability to kill germs potentially harmful to human beings.



**Figure 3. Long-term trend in annual mean of the daily global solar radiation, 1961-2005.**

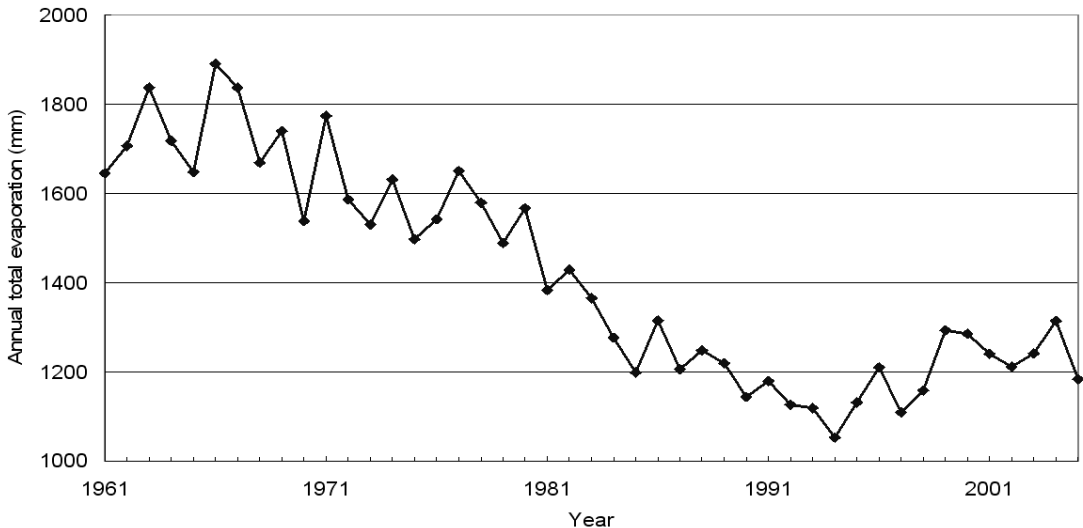
## 5. Evaporation

One aspect of climate change in cities less noticed by people is the decreasing trend in evaporation. Meteorologists measure evaporation by placing a pan of water lying low on the ground and exposing it to the winds and to the sunshine. The time series of annual total evaporation measured at King's Park between 1961 and 2005 is shown in Figure 4. The broad decreasing trend is evident. It could be attributed to the greatly decreased prevailing wind speed and the reduced amount of solar radiation reaching the ground during the day. Thus it is another signature of urbanization. Again, one wonders whether it could mean damp corners remaining damp more than before, providing a favourable environment for germs.

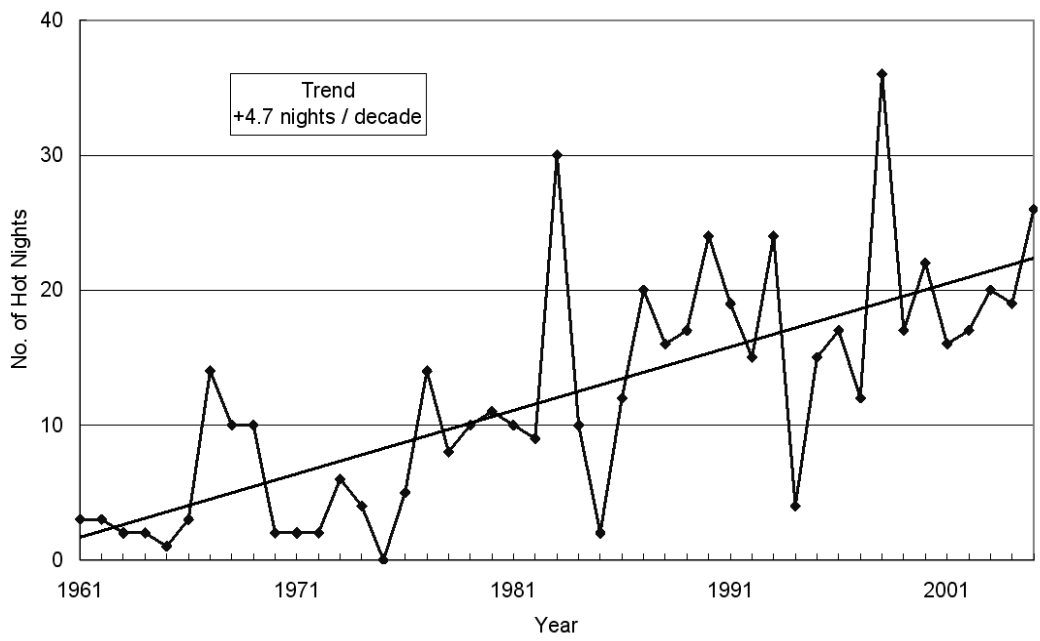
## 6. Thinking about people

In tandem with urbanization in Hong Kong, urban temperature has risen faster than the countryside, winds have gone slow, visibility has deteriorated, less solar radiation is reaching the ground, evaporation rate has gone down, and so on. But does it matter?

For the rich and the elite, it probably does not. They could switch on air-conditioning throughout the year, watch high-definition TV instead of looking at the sky, employ artificial sunlight to get the tan, dry their clothes with electrical devices, etc. Unfortunately, this would raise urban living to an even higher level in terms of high energy consumption, which would in turn cause even greater climate change.



**Figure 4. Long-term trend in annual total evaporation, 1961-2005.**



**Figure 5. Annual number of hot nights from 1961 to 2005.**

For people with lesser means especially the old and the weak, it could however become a life-threatening issue. One aspect of climate change that could “kill” people with chronic diseases

and elderly living alone is the increasing number of hot nights. Figure 5 shows the rise in the numbers of hot nights, that is, nights with a minimum temperature above 28°C, based on Hong Kong Observatory headquarters data, 1961 – 2005. In the 1960s, it was just a few days a year. Now it is roughly 20 days a year. According to the projection of Leung et al. (2004), the figure would rise to 30 by the end of the century.

This city is heading towards a hot, stuffy state of atmosphere. In future summers, the old and the weak living in their tiny rooms in the urban areas will have to face the increasing number of hot nights with no air-conditioning, little wind and the dampness arising from little sun and little evaporation. They also have to fear the attack of more germs than used to be since their natural enemies, viz. fresh air and sunshine, have been reduced in strength. Unfortunately the underprivileged have to look forward to even more tall buildings along the shore or even right at the heart of the urban areas to block the little wind and sunshine left.

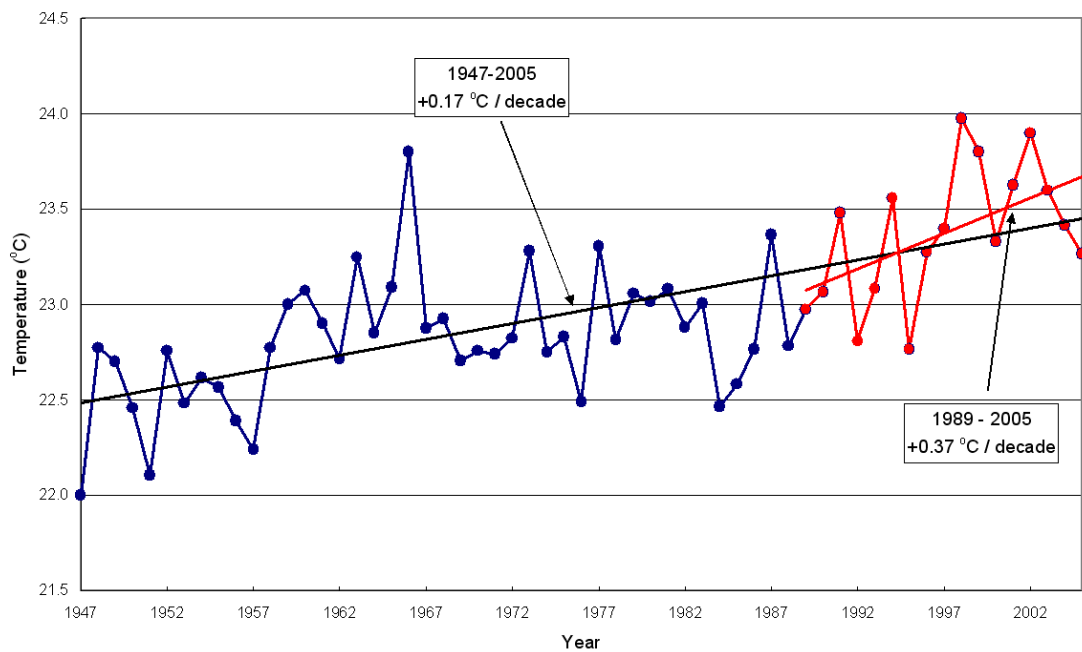
Buildings are meant to benefit people. But we have seen in the meteorological records presented above that buildings have collectively modified the urban climate in a way unfavourable to healthy living. It is high time for us to re-think the fundamentals about how urban living should look like. Much is in the hands of architects and engineers.

### **Acknowledgements**

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**Figure C4. Annual mean temperature recorded at the Hong Kong Observatory Headquarters (1947-2005).**



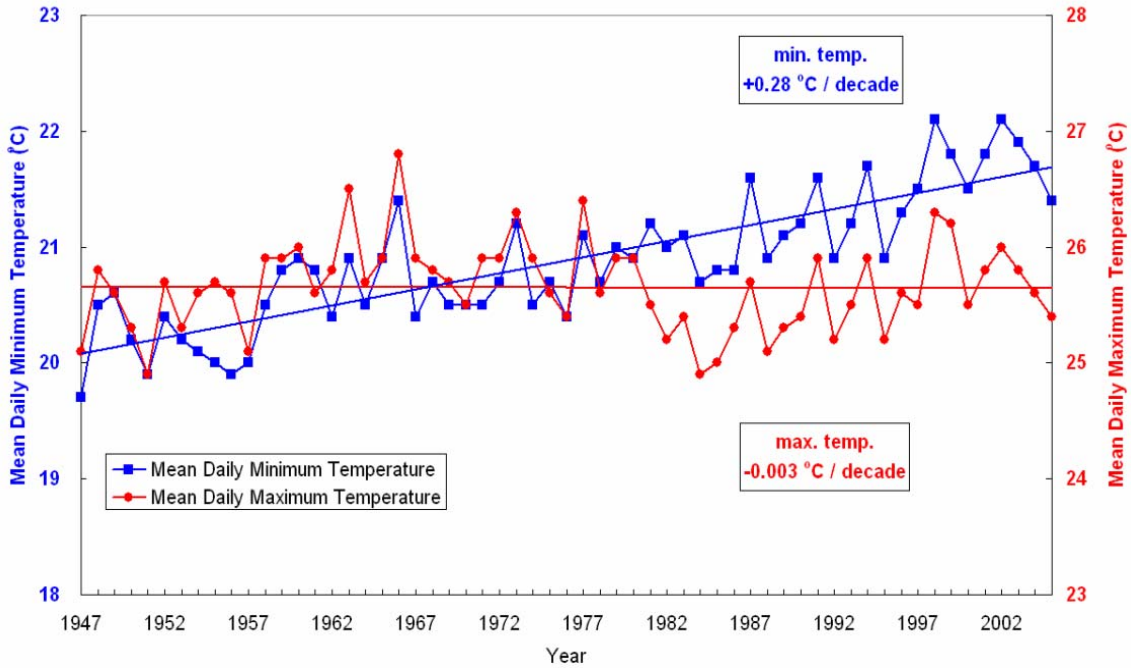


Figure C5. Mean daily maximum (red) and mean daily minimum (blue) temperature of Hong Kong Observatory Headquarters (1947-2005).

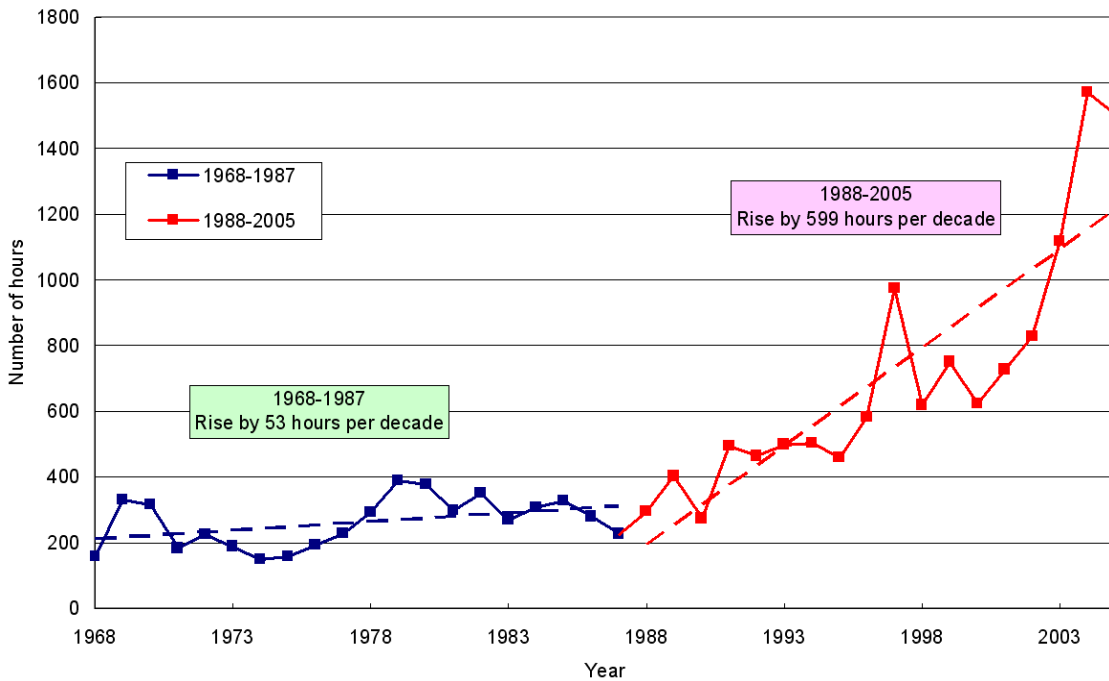


Figure C6. Annual Total Number of Hours with Visibility at the Hong Kong Observatory Headquarters below 8 km from 1968 to 2005 (not counting rain, mist or fog).