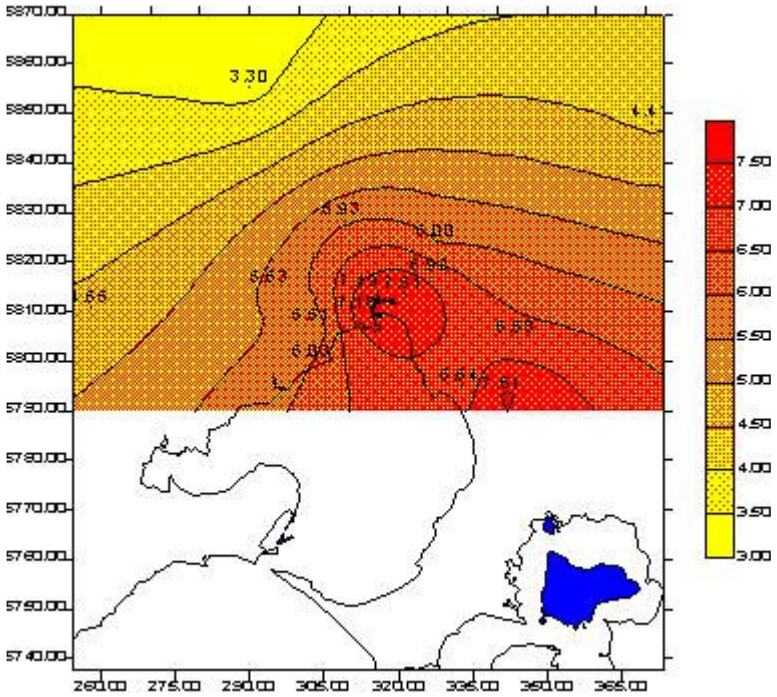
Urban Heat Islands and Climate Change - Melbourne, Australia

C.J.G. (Jon) Morris

School of Earth Sciences, The University of Melbourne, Victoria, Australia



The plot shows the 1985-94 Winter (JJA) Mean Minimum Observed Temperature recorded at 15 sites around Melbourne. The following text explains more about the research.

The results from a recent study in Melbourne have found that the central business district (CBD) and industrial suburbs (IS) retain stored heat from the previous day until sunrise the following morning. This explains why these areas are consistently warmer at night than the outer suburbs and surrounding rural environments. Now climatologists are carefully examining the climate record from Australia's towns and cities to find out whether urban areas have influenced our understanding of the way our climate has changed. The question being asked is, `Have urban areas contributed to the observed trend of warming temperature and influenced our knowledge of global warming?'

The warm nights are due to what has been called the Urban Heat Island (UHI) effect, which is the result of two main features of urban areas. First, buildings, roads and paved surfaces store heat during the day, which is then released slowly over the evening due to the thermal properties of the surface materials and the building geometry which traps the heat stored during the day. The second contributing factor to the UHI is due to the artificial heat released into the urban atmosphere by combustive processes from vehicles, industrial activity and the heat that escapes from commercial and domestic air conditioning.

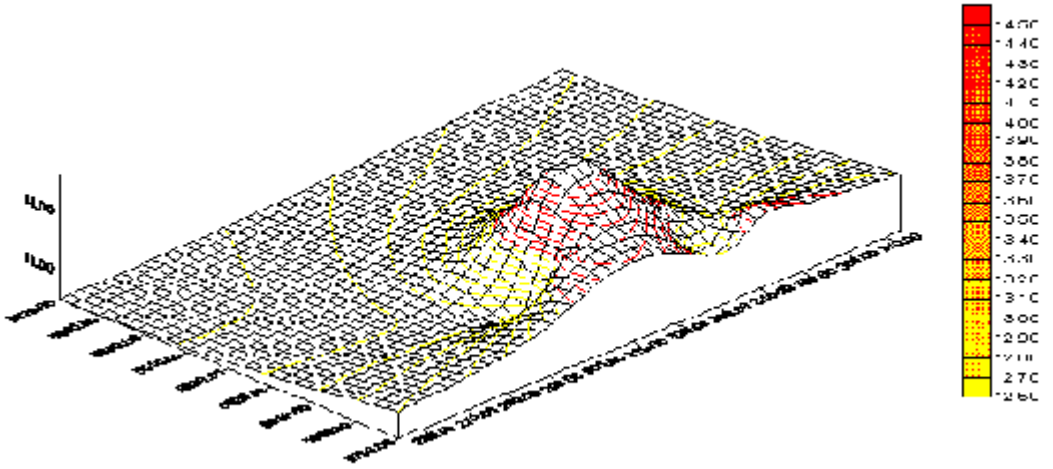
Using a dataset complied from twice daily observations from 1985 to 1994 from weather stations maintained by the Victorian Environmental Protection Authority and the Australian Bureau of Meteorology, results indicate that just prior to sunrise the CBD and IS are on average 4.0 deg C warmer during the summer months and 3.2 deg C warmer during the winter months. Interestingly over the 10 year period the summer months indicated that the CBD was the warmest area, whilst during the winter months the industrial area of Dandenong was 0.3 deg C warmer than the CBD.

These values for the UHI represent its average intensity during all of the weather events between 1985 and 1994. The values have been adjusted to a reference level to account for the effects of topography. The study has also found that the UHI is most pronounced when the wind speed in the CBD and at the airport is less than 3 m/s. On some occasions when there is little or no cloud and wind speeds below 1.5 m/s the heat island may be as high as 10 deg C around midnight. During very windy evenings the heat normally retained by the urban area is dispersed more easily which results in a smaller difference in temperature between the CBD and the outer suburbs.

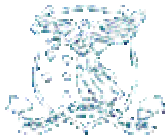
The research of Melbourne's UHI is part of a larger project which is investigating the influence of urban areas on our knowledge of climate change. The global warming issue has been well documented in the media. Knowledge of the observed temperature warming has been derived from a variety of sources, the most important of which is the land based observation network of weather stations maintained by the Australian Bureau of Meteorology. One of the problems with the observed data is that some of it is from weather stations that have been located in the centre of small urban areas.

Whilst large urban areas such as Melbourne have been excluded from the dataset used to determine climate change, the UHI in the small towns may still cause a unrealistic warming in the temperature records used to determine climate change. The research into Melbourne's UHI has been used to more fully understand the physical processes that occur in small towns. The problem with the temperature records from small towns is if climatologists use these records to examine climate change then what they may actually be seeing is how the urban area has warmed as the town has grown, rather than how the larger scale climate has changed.

Whilst climatologists now think that the warming in the temperature record from some small urban areas is partly the result of the UHI, this is not evidence that Australia's climate has remained unchanged rather than warmed over the past 100 years. Average minimum temperatures from many stations over most of Australia have shown an increase of between 0.1 deg C and 0.3 deg C per decade since 1951. Whilst some temperature records from small towns do not represent the large scale climate, it is unlikely to have any major impact upon our estimates of temperature warming over Australia. This is because there are numerous other weather stations located in remote areas such as lighthouses and regions far removed from urban areas that still indicate a warming temperature trend. The research currently taking place in Melbourne and a limited number of small towns in south eastern Australia aims to improve the quality of these particular town's climate records by accounting for the UHI effect in their temperature record and the confidence climatologists have in accurately monitoring and assessing climate change.



The plot above shows the 1985-94 Summer Mean Minimum Potential Temperature contours for Melbourne. This plot shows a UHI of 1.81 deg C, which is determined by subtracting the average value of Melbourne and Laverton airports from the average value of the three inner city sites of Melbourne, Paisley and Alphington. The peak in the contours is located over Melbourne's CBD. The key shows a UHI of 2.0 deg C, with a contour interval of 0.1 deg C.



This research is currently being undertaken in the School of Earth Sciences at The University of Melbourne, Melbourne, Victoria, Australia.

Urban Heat Islands in Small Towns - Deniliquin, Australia

C.J.G. (Jon) Morris

School of Earth Sciences, The University of Melbourne, Victoria, Australia

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This photo shows the position of the Stevenson screen at the back of the Post Office in Deniliquin. The temperature was sampled at this site from 1873-1971. Note the close proximity of buildings and paved areas.

Recent research in Deniliquin suggests that as country towns grow they experience warmer nights. The warming of the nighttime temperature is due to the Urban Heat Island (UHI) effect, which is the result of two main features of urban areas. First, buildings, roads and paved surfaces store heat during the day, which is then released slowly over the evening due to the thermal properties of the surface materials and the building geometry which traps the heat stored during the day. The second contributing factor to the UHI is due to the artificial heat released into the urban atmosphere by combustive processes from vehicles, industrial activity and the heat that escapes from commercial and domestic air conditioning.

The controversy surrounding the role of the UHI on estimates of global warming has focused critical attention on Deniliquin's 136 years of temperature record. Few towns in Australia have a longer history of temperature measurement, hence it is a logical choice for research of the UHI and its effect on our understanding of climate variability.

Scientist's have detected global warming of the earth's atmosphere by various techniques. One technique used in Australia involves looking back at our climate records from many of the Bureau of Meteorology's monitoring stations located over the Australian continent. Unfortunately many of these monitoring stations are not suitable for studying what has happened to our climate over long periods of time due to their short station history. However in Deniliquin the Bureau of Meteorology established a monitoring station in 1858. This station along with many others in Australia are used to evaluate changes in our climate such as global warming and El Nino related climate variability such as drought.

The increase in temperature over Australia is determined by records of regular daily measurements of the air temperature. These are taken at 1.5 meters above the surface in a screen that shields the instruments from direct sunlight, so that the measurement is of the air temperature in the shade. (The Stevenson screens are the white boxes in each image on this page.) The measurements that have been recorded include a temperature measurement for the daytime maximum and the nighttime minimum temperature. Research conducted in Australia has shown that over the past 70 years in

most of Australia the greatest increase in temperature has occurred in the nighttime minimum temperature.

Deniliquin's maximum and minimum temperatures were recorded at the Post Office from 1873 to 1971, before the station was relocated to the airport in 1984. The records from the Post Office indicate that in Deniliquin the annual average minimum temperature increased by 2.1 deg C until 1971. However when the monitoring station was moved out of the urban area, the last 20 years of record shows that the nighttime temperature is 0.6 deg C lower than the previous 98 year average. This indicates that the urban area of Deniliquin may be warmer than its surrounding rural regions. To test this, measurements were taken of the air temperature, wind speed and direction at seven locations along a transect on either side and through the center of the town. During February 1995, measurements in Deniliquin showed that on clear and calm nights, the town centre can be up to 4.2 deg C warmer than beyond the airport.

This is the current site at Deniliquin Airport. It represents a well exposed location away from the urban area and any surface materials which act to moderate the natural energy balance and promote the genesis of a UHI.

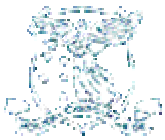
The recent measurements tell scientists that during the years when the minimum temperature was recorded at the Post Office it is conceivable that the measured temperature includes a positive temperature bias caused by Deniliquin's UHI. If climatologists use Deniliquin's temperature record to examine climate change since measurements first began at the Post Office then what they may actually be seeing is how the urban area has warmed as the town has grown, rather than how the larger scale climate has changed.

What researchers want to know is whether the nighttime temperature record for Deniliquin would show the same level of warming if the monitoring station had always been located outside of the urban area and not at the Post Office.

It is unlikely that the urban area of Deniliquin would be up to 4.2 deg C warmer than the rural area under cloudy and windy weather conditions. So after a series of more measurements, researchers hope to identify how Deniliquin's UHI varies between the seasons of the year and during different sorts of weather events. From these measurements climatologists can then critically examine the temperature record and make adjustments for the effect of the UHI on the observed temperature warming in the climate record. The research is on-going and whilst Deniliquin's temperature record before 1971 may not represent the `real' or larger scale climate, climatologists now need to account for this when they derive estimates of climate change.

Whilst researchers now think that the warming in Deniliquin's temperature record is partly the result of the UHI, this is not evidence that Australia's climate has remained unchanged rather than warmed over the past 100 years. Average minimum temperatures from many stations over most of Australia have shown an increase of between 0.1 deg C and 0.3 deg C per decade since 1951. Whilst

climatologists now think that Deniliquin's temperature record does not to represent the large scale climate, it is unlikely to have any significant impact upon our estimates of temperature warming over eastern Australia. This is because Deniliquin is only one monitoring station amongst the many used in Australia for climate variability analysis. The research currently taking place in Deniliquin and a limited number of other urban areas in south eastern Australia aims to improve the quality of these particular town's climate records and the confidence climatologists have in accurately monitoring and assessing climate change.



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