



**Response to ESC Enquiries on the CSIRO
Report on “Projected changes in temperature
and heating degree-days for Melbourne and
Victoria, 2008-2012”**

R. Suppiah and P. H. Whetton

October 2007

*Undertaken for the SP-AusNet by the Climate Impact and
Risk Group, CSIRO Marine and Atmospheric Research*



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INTRODUCTION

This sensitivity analysis addresses queries raised by the Essential Services Commission of Victoria on the CSIRO report (Suppiah and Whetton, 2007 – hereafter denoted as SW) entitled "Projected changes in temperature and heating degree-days for Melbourne and Victoria".

The original report outlined the CSIRO's best estimate of the projected temperature, Heating Degree-Days (HDDs) and Effective Degree-Days (EDDs). The methodologies employed and time series included were selected by CSIRO in the interests of achieving the most reliable estimate. When the study was conducted, complete data were not available for 2006, and it only used data up to the end of 2005.

In this analysis, we respond to the ESC's two major queries on the findings of SW:

1. What would be the impact on the 2006 baseline estimate if we include the observed temperatures for 2006?
2. What would be the impact on the baseline estimate of selecting a different starting point to 1950, i.e. 1960, 1970 or 1980?

1. What would be the impact on the 2006 baseline estimate if we include the observed temperatures for 2006?

Here we have analysed annual average temperatures for the Melbourne weather station (specifically central Melbourne) from 1950 to 2006 to detect any changes, if any, between baseline values for 2006 based on two different periods, 1950 to 2005 and 1950 to 2006. In the SW, the baseline value for 2006 was estimated from linear trend from 1950 to 2005 and the end point was 16.13°C.

To investigate the sensitivity of the projections to baseline temperature for 2006, we have reproduced relevant time series from Figure 12 in the previous study by SW which include estimation of annual average temperature for 2006. The best fit curves in Figure 1a are based on the linear analysis employed in SW for the two periods, 1950-2005 and 1950-2006. The baseline estimate for 2006 is 16.16°C based on annual data from 1950 to 2006, as shown in Table 1. The value of 16.16°C is directly read from the trend line for the year 2006. If we were to substitute the new annual temperature estimate for 2006 derived from the linear temperature trend analysis (16.16°C) to the non-linear relationship between daily HDD and daily EDD derived in SW, this would give a baseline EDD value of 1315 as the new baseline value for 2006. This baseline temperature value is 0.03°C higher than the baseline figure for 2006 given in SW 2007 (based on the end point of the fitted trend for 1950-2005), which gave an annual EDD value of 1321, and 0.01 higher than the 2006 figure that would have been obtained if the trend up to 2005 had been extrapolated by one further year. The annual temperature value derived from the extrapolation

method is 16.15°C , which corresponds to the annual EDD value of 1318 (see Table 1).

We also estimated the baseline value for 2006 using a non-linear trend in annual temperature to observe any difference between the baseline values calculated using linear and non-linear methods. The baseline value estimated for 2006 based on a non-linear analysis (Figure 1b) gives slightly higher values for both of these periods, 16.45°C for 1950-2005 and 1950-2006, respectively (see Table 1). If we were to substitute the annual temperature estimate for 2006 derived from the non-linear temperature trend analysis (16.45°C) to the non-linear relationship between daily HDD and daily EDD in SW, this would give a baseline EDD value of 1246.5. Note that the upward inflection in the last five years in the non-linear fit may represent a real shift in the background climate, or may represent a natural fluctuation.

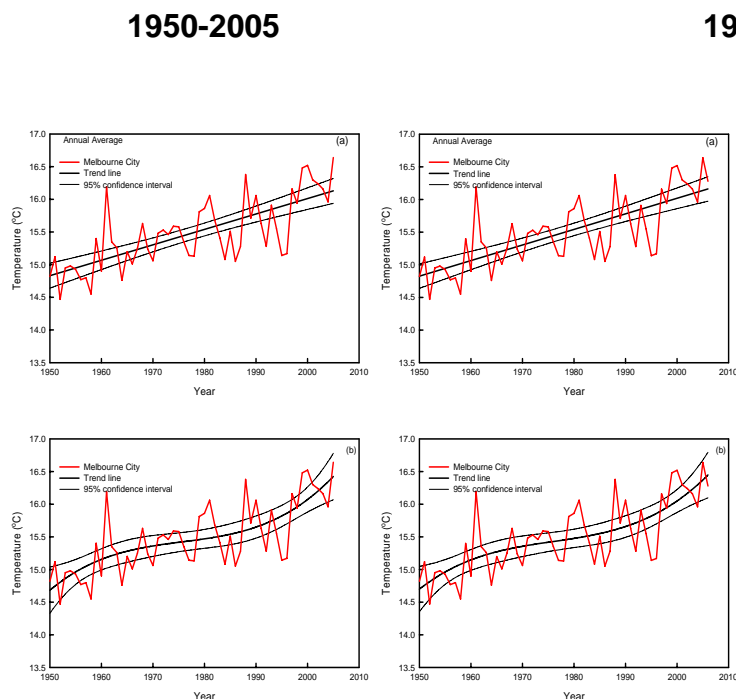


Figure 1. Interannual variations and trends in annual average temperature at central Melbourne from (a) linear trends and (b) from non-linear trend analysis for the periods 1950-2005 (left panels) and 1950-2006 (right panels). The 95% confidence levels are also shown for each plot.

Table 1: Estimates of annual baseline temperature and EDD for 2006 using two different periods. The annual temperature for 2006 was estimated based on linear and non-linear trend analyses. EDD values were estimated based on the non-linear relationship between daily temperature and daily EDD as in the previous study by SW. EDD values in column 3 correspond to temperature values in column 2 and EDD values in column 5 correspond to temperature values in column 4. The estimate for 2006 marked with an asterisk is based on extrapolating the annual trend line fitted to 1950-2005 by one year.

Period	Estimated average temperature (°C) for 2006 – based on the linear trend in temperature	Estimated EDD (units) for 2006- based on the non-linear relationship between daily temperature and EDD.	Estimated average temperature (°C) for 2006 – based on the non-linear trend in temperature	Estimated EDD (units) for 2006- based on non-linear relationship between daily temperature and EDD.
SW	16.13	1321	-	-
1950-2005	16.15*	1318	16.45*	1246.5
1950-2006	16.16	1315	16.45	1246.5

In conclusion, inclusion of data for 2006 increases the estimate of baseline temperature and lowers the estimated baseline EDD. The increase in baseline temperature is by 0.03°C compared to baseline figure given in SW and by 0.01°C compared the 2006 figure obtained through simple extrapolation of the trend line given in SW. Baseline EDD decreases by 6 units compared to SW and by three units compared to the value based on extrapolating the trend line. This study also indicates that an upward revision of 0.03°C may be appropriate for the projected temperatures for 2007 to 2012 given in SW..

2. What would be the impact of selecting a different starting point for the baseline estimate, i.e. 1960, 1970, or 1980?

In the previous study, we estimated the 2006 baseline annual average temperature, HDD and EDD based on data from 1950 to 2005. In the present study, we have selected a number of different starting points to estimate the baseline. These are 1950-2005, 1950-2006, 1960-2006, 1970-2006, 1980-2006, 1990-2006, 1991-2006 and 1970-2005. The period 1970-2005 was also used by VENCORP (2006) to estimate the baseline value for 2006 in their study. Figures 2 and 3 show interannual variability and both the linear and non-linear trends in annual average temperature at the Melbourne weather station for the periods 1960-2006 and 1970-2006. Figure 4 shows the equivalent data for 1980-2006 and 1990-2006, but results based on non-linear trends are not shown as the confidence levels are noisy.

The baseline annual average temperature derived from the various periods and the differences between the baseline value of 1950-2006 and other periods are summarised in Table 4. The differences are smaller over longer periods of analysis. Moreover, stronger warming has been observed since 1980 which mainly contributes to a significant difference for the periods after 1980. Other

factors, such as interannual variability also play a significant role in determining the slope and the baseline values for 2006. Smaller samples can give large differences, as shown for the period 1991-2006. In summary, the baseline values derived from longer data sets give more reliable values with reduced errors and should be preferred.

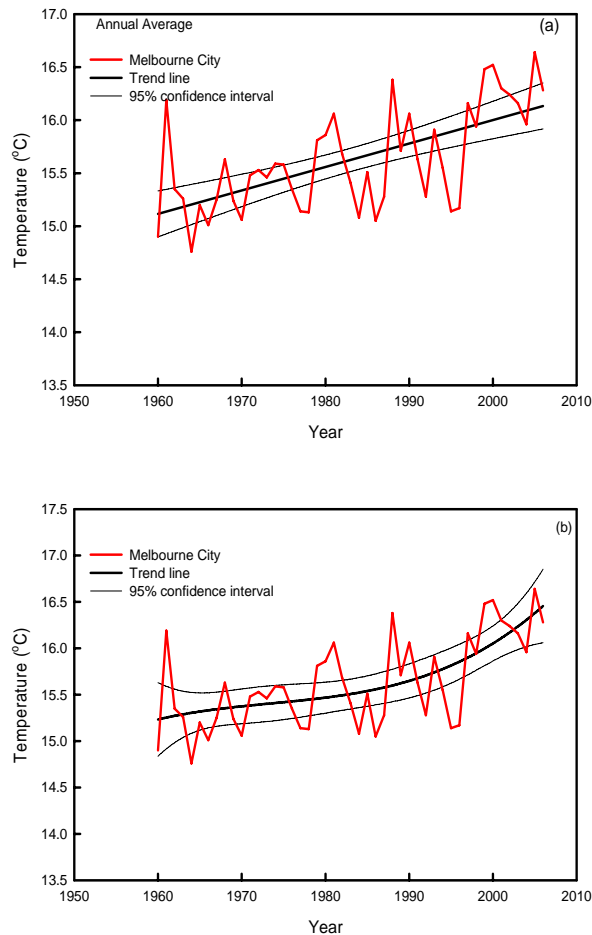


Figure 2. Interannual variations and trends in annual average temperature at central Melbourne from (a) linear trend analysis and (b) non-linear trend analysis for the period 1960-2006. The 95% confidence levels are also shown for each plot.

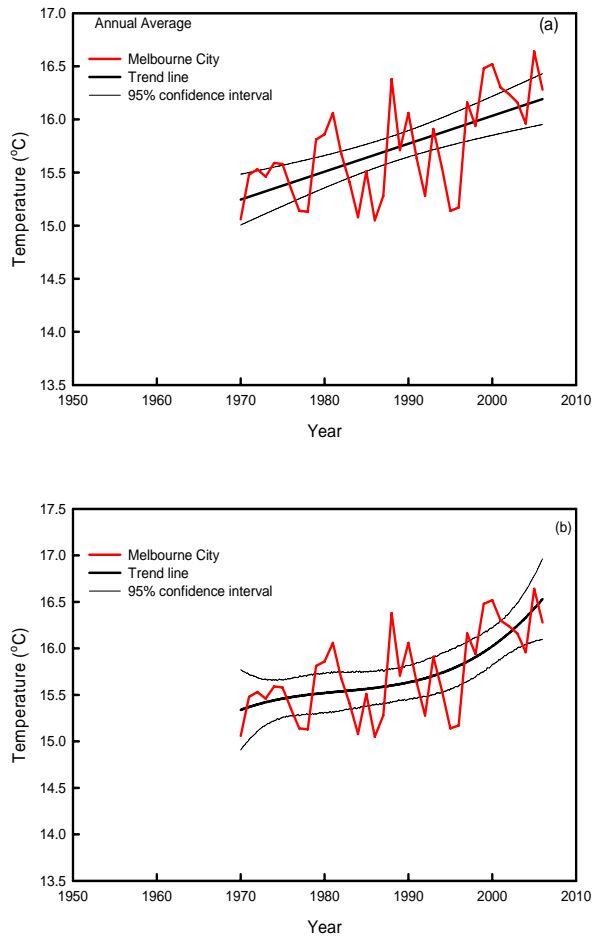


Figure 3. Interannual variations and trends in annual average temperature at central Melbourne from (a) linear trend analysis and (b) from non-linear trend analysis for the period 1970-2006. The 95% confidence levels are also shown for each plot.

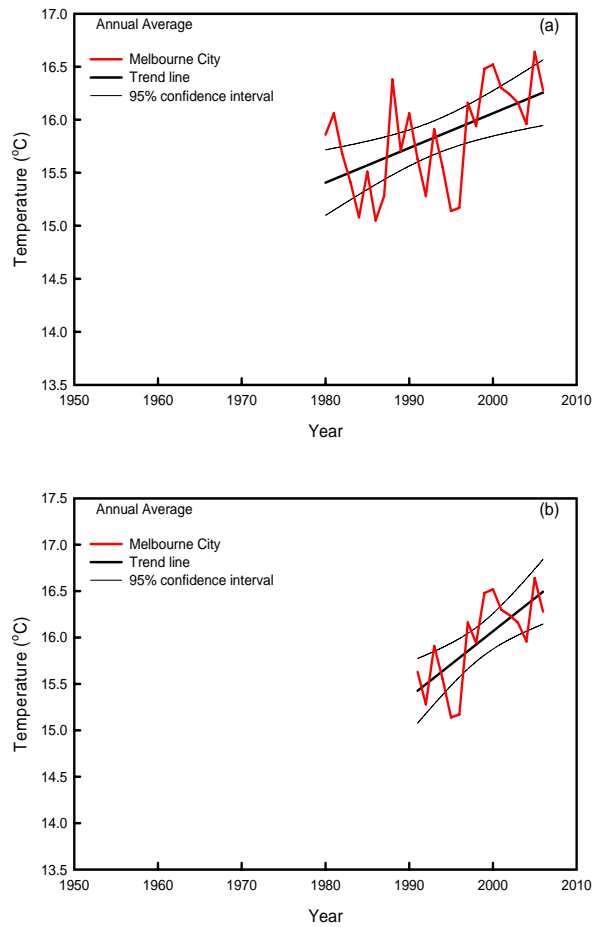


Figure 4. Interannual variations and trends in annual average temperature at central Melbourne from linear trend analysis for (a) the period 1980-2006 and (b) the period 1990-2006. The 95% confidence levels are also shown for each plot.

Table 2. Differences between the baseline annual average temperature (°C) values for 2006 derived from the period 1950-2006 and other periods. Results shown in columns 2 and 3 are based on **linear trends** and results shown columns 4 and 5 are based on **non-linear trends**. Results in column 3 are based on temperatures in column 2, while results in column 5 are based on results in column 4.

Period	Baseline temperature for 2006 based on linear trend	Difference between 1950-2006 and other periods	Baseline temperature for 2006 based on non-linear trend	Difference between 1950-2006 and other periods
1950-2006	16.16	-	16.45	
1960-2006	16.13	-0.03	16.46	+0.01
1970-2006	16.19	+0.03	16.53	+0.08
1980-2006	16.26	+0.10	16.38	-0.07
1990-2006	16.43	+0.27	16.46	+0.01

3. References

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