Projected changes in temperature and heating degree-days for Melbourne, 2012-2017

Updating: "Projected changes in temperature and heating degree-days for Melbourne and Victoria, 2006-2012”

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Important Notice

Use of this report

Contents

List of Figures

List of Tables

1. INTRODUCTION

This is an update of the previous report on “Projected changes in temperature and heating degree-days for Melbourne and Victoria, 2006-2012” submitted to SP-AusNet in 2007. In the previous study, the contribution of urbanisation represented by the urban heat island index (UHI) was calculated as the difference between observations at the Melbourne central weather station and the grid point data produced by the Bureau of Meteorology representing the Melbourne region in their gridded data set, which is based on rural stations that do not have urban influence. Details of this method can be found in the two previous reports (Suppiah *et al*., 2001; Suppiah and Whetton, 2007). Once the urbanisation component was calculated, remaining contributions to the trend in Melbourne central temperature are assumed to be due to natural variability and the anthropogenic effect. Temperature projections used in the previous report were based on simulations performed for the Third Assessment Report of the Intergovernmental Panel on Climate Change in 2001 (IPCC, 2001).

In this brief update the temperature projections are extended out to 2017. In doing this the following assumptions have been made:

- The warming trend in Melbourne due to growing urbanisation estimated in previous report on the period from 1950 to 2005 is assumed to continue through the new projection period of 2012-2017.

- The warming trend in Melbourne due to the anthropogenic global climate change used in the previous report may be extended into the new projection period.

- The availability of new observed temperatures in Melbourne between 2006 and 2010 does not significantly modify the long-term trends from 1950 estimated in the previous report, i.e. the rate of increase in average temperature at Melbourne central weather station based on the records from 1950 to 2010 does not show a significant difference compared to the period from 1950 to 2005.

The first assumption is reasonable given ongoing urban growth in Melbourne. Although new projections were prepared for Australia based on new model simulations after the previous report, and the second assumption is reasonable for this brief assessment given that differences in projected warming between the two releases, and deviations form a linear rate of warming, were relatively minor (Suppiah *et al*, 2007). The third assumption would be expected to be valid on statistical grounds but is tested further in the next section. In the conclusions, we discuss further how the results may differ if the methodology used in the previous study was fully applied using up to date projections (thus avoiding the above simplifying assumptions).

2. MELBOURNE TEMPERATURE TRENDS, CONTRIBUTION OF URBANISATION AND GREENHOUSE WARMING

On the basis of linear trends from 1950 to 2010, Melbourne's maximum temperature increased by (0.24°C per decade), the minimum temperature increased by (0.38°C per decade) and the average temperature increased by (0.31°C per decade). The larger increase in minimum temperature is the reflection of the continued increase in urbanisation in Melbourne due to a significant increase in infrastructure during that period. Figure 1 shows that there is no major change in the average temperature trend in Melbourne by adding the years from 2007 to 2010 compared to Figure 12 in our previous report (Suppiah and Whetton, 2007). In this report, we used the same baseline value of the year 2006 derived for the previous report from a linear trend applied to average Melbourne temperature from 1950 to 2005. Projected changes in average temperature, HDDs and EDDs are given in relation to the year 2006. It is evident from Figure 1, that the year 2007 had highest temperature during this period. The difference based on trend lines between these plots is +0.09°C for the year 2006, which is small. Given this, we can have confidence in extending the projections from the previous report out to 2017.

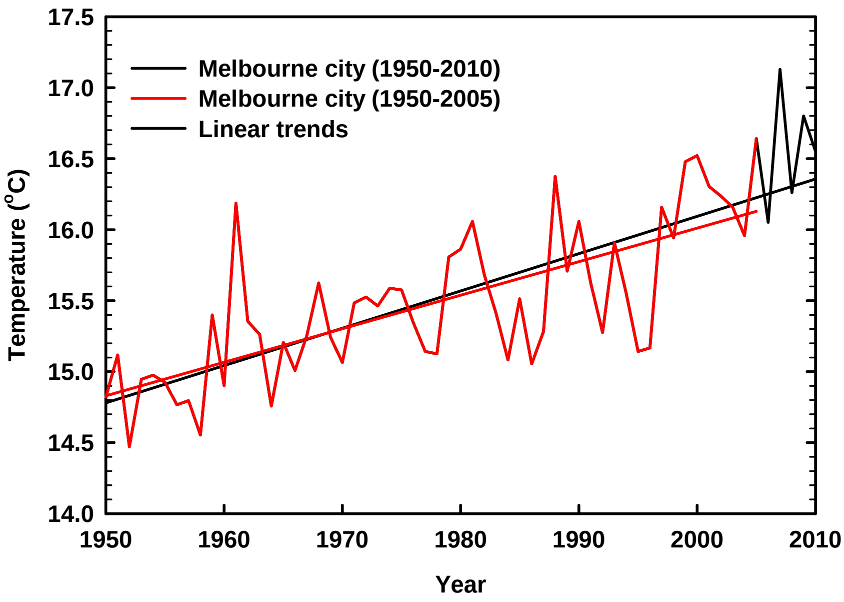

Figure 1. Interannual variations and trend in annual average temperature at Melbourne central weather station (station number 86071) from 1950 to 2010 and also from 1950 to 2005 for comparison of trends between these two lines. Data source: Australian Bureau of Meteorology.

The urbanisation contribution expressed is an index called Urban Heat Island (UHI) index. Figure 2 shows the contributions of UHI and anthropogenic climate change for low and high emission scenarios upto 2017. In this report, projected temperature values for uhi+low anthropogenic warming, uhi+average anthropogenic and uhi+high anthropogenic warming indicate that low warming is a combination of low model response and low emissions (B1), mid warming is a combination of mid emissions (A2) and model response and high warming is a combination of high emissions (A1FI) and model response. Further details on emission scenarios can be found in Special Report on Emission Scenarios (SRES, 2000). Moreover, the range in projected changes is mainly driven by model-to-model differences. - Further details of the methodology and projected temperature for Melbourne were given in the previous report (Suppiah and Whetton, 2007).

The UHI contribution to seasonal and annual is 0.01 °C per year. The compounding values of the UHI increased from 0.073°C in 2012 to 0.13°C in 2017. The warming for low to high anthropogenic climate change ranges between 0.031°C and 0.165°C for 2012 and between 0.057°C and 0.305°C for 2017. We assume that the warming observed in Melbourne up to 2010 includes the effects of urbanisation, natural variability and greenhouse warming.

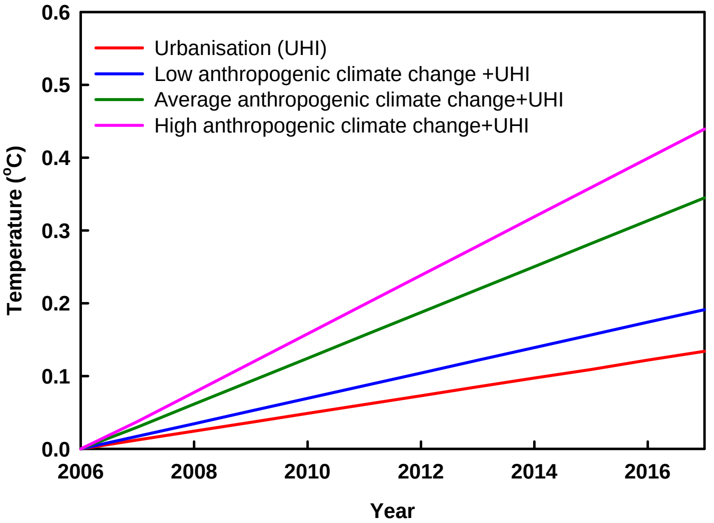

Figure 2. Annual urban heat island (UHI) plus (low, average, high) anthropogenic climate change warming trends for central Melbourne from 2006 to 2017.

3. BASELINE TEMPERATURES, HEATING DEGREE-DAYS AND EFFECTIVE DEGREE-DAYS

Methods used to calculate baseline temperature, Heating Degree-Days (HDDs) and Effective Degree-Days (EDDs) for the winter half, summer half and annual for 2012 are as same in the previous study (Suppiah and Whetton, 2007). Definitions for HDDs and EDDs and their computational procedures were given elsewhere (VENCorp, 2003, 2006; Suppiah and Whetton, 2007). The winter half year is from May to October of the current year, summer half is from November of the previous year to April of the current years. The annual values are from January to December of the current year.

The baseline temperatures for 2012 for winter half are 13.06, 13.09, 13.16 and 13.21 °C that include an endpoint based on the linear interpolation of Melbourne central temperature plus UHI, plus low, mid and high greenhouse warming scenarios, respectively. The baseline temperatures for 2012 for summer half are 19.36, 19.39, 19.47 and 19.52 °C that include an endpoint based on the linear interpolation of Melbourne central temperature plus UHI, plus low, mid and high greenhouse warming scenarios, respectively. The baseline temperatures for 2012 for annual are 16.21, 16.24, 16.32 and 16.36 °C that include an endpoint based on the linear interpolation of Melbourne central temperature plus UHI, plus low, mid and high greenhouse warming scenarios, respectively. The corresponding baseline values for HDD units for winter half are 987.6, 981.9, 967.0 and 957.9, for summer half are 178.2, 174.9, 166.7 and 161.9, and for annual are 1165.8, 1156.8, 1133.7 and 1119.8 for 2012. The corresponding EDD units for 2012 for winter half are 1215.9, 1206.6, 1183.2 and 1168.8, and for summer half are 102.7, 100.2, 94.4 and 91.2 and for annual are 1318.5, 1306.8, 1277.6 and 1260.0.

4. PROJECTED CHANGES IN SEASONAL TEMPERATURES, HDDS AND EDDS

Projected increases in seasonal (winter half and summer half) and annual temperatures, HDDs and EDDs from 2012 to 2017 are given in Tables 1, 2 and 3. Projected Melbourne winter half mean temperature for mean plus UHI, plus low, mid and high greenhouse warming increases by 0.014, 0.019, 0.032 and 0.039°C per year between 2012 and 2017. Summer half temperature increases by 0.013, 0.019, 0.035 and 0.045 °C per year between 2012 and 2017 for the combined effects of UHI, low, mid and high greenhouse warming. Mean annual temperature also increases by 0.013, 0.019, 0.035 and 0.045 °C per year between 2012 and 2017 for the combined effects of UHI, low, mid and high greenhouse warming. The increase in mean annual temperatures of 0.035°C for the UHI plus mid greenhouse warming scenario is consistent with the trend observed from 1950 to 2010, which trend implied an increase in mean annual temperature of 0.031°C (0.31°C per decade).

Since temperature and HDDs as well as temperature and EDDs have negative relationship, projected HDDs and EDDs show decreases between 2012 and 2017. Projected winter half HDDs decrease by -0.1, -1.1, -4.2 and -6.2 units per year between 2012 and 2017 for combined effects of UHI, and low, mid and high greenhouse warming. Projected summer half HDDs decrease by -0.3, -0.9, -2.6 and -3.6 units per year between 2012 and 2017 for combined effects of UHI, and low, mid and high greenhouse warming. Projected annual HDDs decrease by -0.4, -2.1, -6.8 and -9.7 units per year between 2012 and 2017 for combined effects of UHI, low, mid and high greenhouse warming.

Projected winter half EDDs decrease by -0.1, -1.9, -6.6 and -9.8 units per year between 2012 and 2017 for combined effects of UHI, and low, mid and high greenhouse warming. Projected summer half EDDs decrease by -0.4, -0.8, -1.8 and -2.5 units per year between 2012 and 2017 for combined effects of UHI, and low, mid and high greenhouse warming. Projected annual EDDs decrease by -0.5, -2.7, -8.5 and -12.3 units per year between 2012 and 2017 for combined effects of UHI, low, mid and high greenhouse warming.

5. CONCLUSIONS

Projected changes in seasonal and annual temperatures, HDDs and EDDs are calculated using the method described in the previous report by Suppiah and Whetton (2007). In this update, it is assumed that continuing trends in temperature, the contribution of urbanisation and greenhouse warming trends remain the same as in the previous study. We would estimate that a more thorough study which fully employed observations for the intervening years of 2007 to 2010 and direct model output for those years from more up to date simulations would not lead to estimates significantly different from those provided here. This is because the additional data has little impact on the observed long term warming trend in Melbourne average temperature and the model-estimated anthropogenic warming trend is very similar for 2012-2017 to what it is in the previous five years. Both previous (CSIRO, 2001) and latter (CSIRO and Bureau of Meteorology, 2007) climate change projections for Melbourne have the similar increase in average temperature of 0.9°C by 2030. Therefore, Melbourne average temperature is projected to continue to increase, and hence, HDDs and EDDs to continue to decrease between 2012 and 2017.

6. ACKNOWLEDGEMENTS

We acknowledge the modelling groups for providing their data for analysis, the Program for Climate Model Diagnosisand Intercomparison (PCMDI) for collecting and archiving the model output, and the JSC/CLIVAR Working Group on Coupled Modelling (WGCM) for organising the model data analysis activity. The multi-model data archive is supported by the Office of Science, US Department of Energy.

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TABLES

Table 1. Projected average temperature (°C) for Melbourne central for winter, summer halves and annual from 2006 to 2017. Baseline values of seasonal and annual temperatures in 2006 were added to four cases, urban heat island (UHI) growth, UHI plus low greenhouse warming (lgw), UHI plus average greenhouse warming (agw) and UHI plus high greenhouse warming (hgw).

Winter-half

Year	UHI	UHI+lgw	UHI+agw	UHI+hgw
2006	12.98	12.98	12.98	12.98
2007	12.99	12.99	13.00	13.01
2008	13.00	13.01	13.04	13.05
2009	13.02	13.03	13.07	13.09
2010	13.03	13.05	13.10	13.13
2011	13.04	13.07	13.13	13.17
2012	13.06	13.09	13.16	13.21
2013	13.07	13.11	13.19	13.25
2014	13.08	13.12	13.23	13.29
2015	13.10	13.14	13.26	13.33
2016	13.11	13.16	13.29	13.37
2017	13.12	13.18	13.32	13.41

Summer-half

Year	UHI	UHI+lgw	UHI+agw	UHI+hgw
2006	19.28	19.28	19.28	19.28
2007	19.29	19.30	19.31	19.32
2008	19.31	19.32	19.34	19.36
2009	19.32	19.34	19.37	19.39
2010	19.33	19.35	19.40	19.43
2011	19.35	19.37	19.44	19.47
2012	19.36	19.39	19.47	19.52
2013	19.37	19.41	19.50	19.56
2014	19.39	19.43	19.54	19.60
2015	19.40	19.45	19.57	19.65
2016	19.41	19.47	19.61	19.69
2017	19.43	19.49	19.64	19.74

Annual

Year	UHI	UHI+lgw	UHI+agw	UHI+hgw
2006	16.13	16.13	16.13	16.13
2007	16.14	16.15	16.16	16.16
2008	16.16	16.16	16.19	16.20
2009	16.17	16.18	16.22	16.24
2010	16.18	16.20	16.25	16.28
2011	16.20	16.22	16.28	16.32
2012	16.21	16.24	16.32	16.36
2013	16.22	16.26	16.35	16.41
2014	16.24	16.28	16.39	16.45
2015	16.25	16.30	16.42	16.50
2016	16.26	16.31	16.46	16.54
2017	16.28	16.33	16.49	16.59

Table 2. Projected average HDDs for Melbourne central for winter, summer halves and annual from 2006 to 2017. Baseline values of seasonal and annual HDDs in 2006 were added to four cases, urban heat island (UHI) growth, UHI plus low greenhouse warming (lgw), UHI plus average greenhouse warming (agw) and UHI plus high greenhouse warming (hgw).

Winter-half

Year	UHI	UHI+lgw	UHI+agw	UHI+hgw
2006	988.1	988.1	988.1	988.1
2007	988.1	987.2	984.9	983.6
2008	988.0	986.2	981.5	978.9
2009	987.9	985.1	978.1	973.9
2010	987.8	984.1	974.5	968.8
2011	987.7	983.0	970.8	963.5
2012	987.6	981.9	967.0	957.9
2013	987.5	980.9	963.1	952.2
2014	987.5	979.7	959.0	946.2
2015	987.4	978.6	954.8	940.0
2016	987.3	977.4	950.5	933.7
2017	987.2	976.3	946.1	927.1

Summer-half

Year	UHI	UHI+lgw	UHI+agw	UHI+hgw
2006	180.2	180.2	180.2	180.2
2007	179.9	179.4	178.1	177.4
2008	179.5	178.5	175.9	174.5
2009	179.2	177.6	173.7	171.5
2010	178.9	176.7	171.4	168.4
2011	178.5	175.8	169.0	165.2
2012	178.2	174.9	166.7	161.8
2013	177.9	174.0	164.2	158.5
2014	177.5	173.0	161.7	155.0
2015	177.2	172.1	159.1	151.4
2016	176.8	171.2	156.4	147.7
2017	176.5	170.2	153.7	144.0

Annual

Year	UHI	UHI+lgw	UHI+agw	UHI+hgw
2006	1168.4	1168.4	1168.4	1168.4
2007	1167.9	1166.5	1163.1	1161.0
2008	1167.5	1164.6	1157.5	1153.3
2009	1167.1	1162.7	1151.9	1145.4
2010	1166.7	1160.8	1146.0	1137.2
2011	1166.2	1158.8	1139.8	1128.6
2012	1165.8	1156.8	1133.7	1119.8
2013	1165.4	1154.8	1127.2	1110.7
2014	1164.9	1152.8	1120.6	1101.3
2015	1164.5	1150.7	1113.8	1091.6
2016	1164.1	1148.6	1106.9	1081.7
2017	1163.7	1146.5	1099.7	1071.4

Table 3. Projected average EDDs for Melbourne central for winter, summer halves and annual from 2006 to 2017. Baseline values of seasonal and annual EDDs in 2006 were added to four cases, urban heat island (UHI) growth, UHI plus low greenhouse warming (lgw), UHI plus average greenhouse warming (agw) and UHI plus high greenhouse warming (hgw).

Winter-half

Year	UHI	UHI+lgw	UHI+agw	UHI+hgw
2006	1216.7	1216.7	1216.7	1216.7
2007	1216.6	1215.1	1211.6	1209.5
2008	1216.5	1213.5	1206.2	1202.0
2009	1216.3	1211.8	1200.9	1194.2
2010	1216.2	1210.1	1195.2	1186.1
2011	1216.0	1208.4	1189.2	1177.6
2012	1215.9	1206.6	1183.2	1168.8
2013	1215.7	1204.8	1177.0	1159.6
2014	1215.6	1203.0	1170.5	1150.2
2015	1215.5	1201.1	1163.9	1140.4
2016	1215.3	1199.2	1157.1	1130.3
2017	1215.2	1197.3	1150.1	1119.8

Summer-half

Year	UHI	UHI+lgw	UHI+agw	UHI+hgw
2006	104.7	104.7	104.7	104.7
2007	104.3	103.9	103.1	102.6
2008	104.1	103.2	101.4	100.4
2009	103.7	102.5	99.7	98.2
2010	103.4	101.7	98.0	95.9
2011	103.0	100.9	96.2	93.6
2012	102.7	100.2	94.5	91.2
2013	102.3	99.4	92.6	88.8
2014	101.9	98.6	90.8	86.3
2015	101.6	97.8	89.0	83.8
2016	101.2	97.0	87.1	81.2
2017	100.8	96.2	85.2	78.6

Annual

Year	UHI	UHI+lgw	UHI+agw	UHI+hgw
2006	1321.4	1321.4	1321.4	1321.4
2007	1320.9	1319.1	1314.7	1312.1
2008	1320.5	1316.7	1307.6	1302.4
2009	1320.0	1314.3	1300.6	1292.4
2010	1319.5	1311.8	1293.1	1282.0
2011	1319.0	1309.3	1285.4	1271.2
2012	1318.5	1306.8	1277.7	1260.0
2013	1318.0	1304.2	1269.6	1248.4
2014	1317.5	1301.6	1261.3	1236.5
2015	1317.0	1298.9	1252.9	1224.2
2016	1316.5	1296.2	1244.2	1211.5
2017	1316.0	1293.5	1235.3	1198.4

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2 December 2011

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Envestra

Via Email: Penny.Whetton@csiro.au

Dear Penny,

Update of 2006 Report to 2013-17

Envestra, SP Ausnet and MultiNet Gas ("**the clients**") wish to engage the Commonwealth Scientific and Industrial Research Organisation ("**CSIRO**") to update the findings of the March 2006 report "*Projecting changes in temperature and heating degree-days for Melbourne and Victoria*". The update is expected to be based on the existing data but the forecast period will extend to calendar year 2017.

The clients expect the CSIRO team to comprise Penny Whetton, senior principal research scientist, and Ramasamy Suppiah.

The update is expected to be provided by no later than 15 January 2012.

The fee for the updated report will be capped at $10,000 (exclusive of GST).

The parties to CSIRO's Consulting Services Agreement will be:

Envestra Limited – ABN 19 078 551 685
SP Ausnet Limited – ABN 43 086 015 036
MultiNet Gas – ACN 104 036 937

The primary contact for the clients will be Peter Bucki, Senior Regulatory Analyst at Envestra; phone number 08 8418 1112 or email peter.bucki@envestra.com.au. Please contact Peter if you have any further queries.

Yours sincerely,

Craig de Laine
Manager, Network Regulation and Assistant Treasurer
Envestra