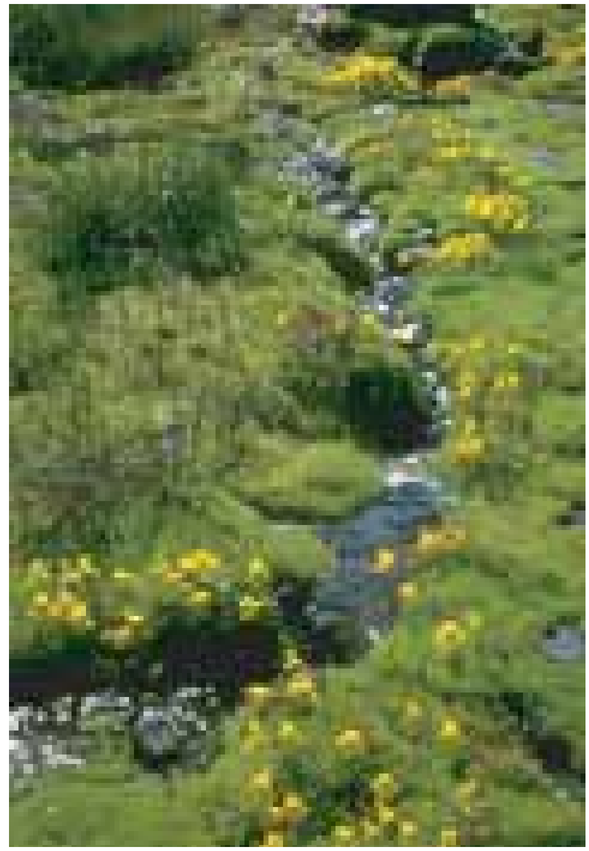
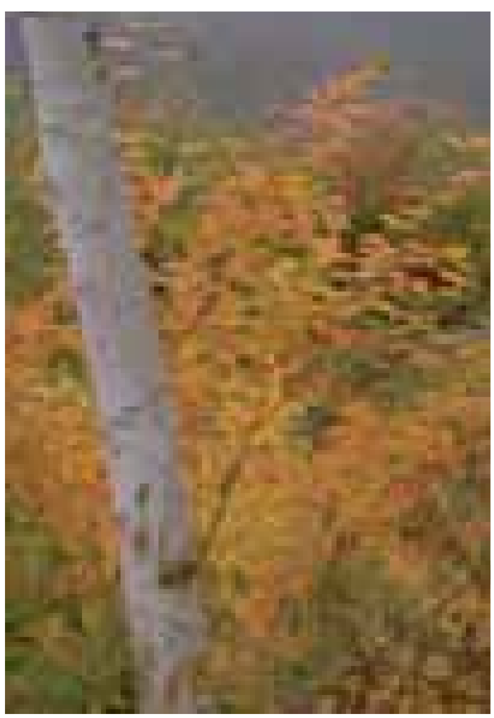
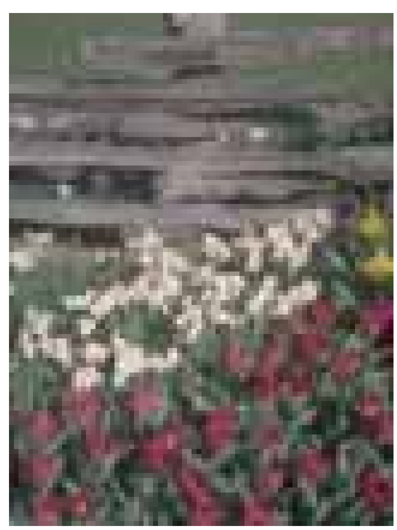


Historical and Projected Temperature and Precipitation Trends in the Annapolis Valley, Nova Scotia

Annapolis Valley Climate Change Policy Response Pilot Project
Technical Report

Stephanie Mehlman, M.Sc.
Climate Change Issues Coordinator
Clean Annapolis River Project
March 2003





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For more information about the VSI, see their website:
http://www.vsi-isbc.ca/eng/index.cfm

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TABLE OF CONTENTS

PART I

HISTORICAL RECORD ANALYSIS

PART II
PLAUSIBLE FUTURE CLIMATE SCENARIO

PART III
OVERALL SUMMARY, IMPLICATIONS AND REFERENCES

APPENDICES

List of Figures – Part I

List of Figures – Part II

List of Figures – Part III

List of Tables – Part I

List of Tables – Part I continued…

List of Tables – Part II

List of Tables – Part III

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The historical analysis in Part I was completed with the assistance of Karen Sutherland and Gary Lines, both with Environment Canada, Meteorological Service of Canada, Atlantic Region, Climate Change Division. Their assistance and experience with this analysis was invaluable.

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ABSTRACT

This study was undertaken to provide, under one cover, information on historical and projected temperature and precipitation trends at Greenwood and Kentville, both sites centrally located within the Annapolis Valley of Nova Scotia. The Valley is a principal agricultural region within Nova Scotia. This report thus constitutes an archive of analyzed data, readily available to academics, impacts researchers, agronomists, foresters, and other stakeholders having a vested interest in historical trends and projected climate change scenarios for the Annapolis Valley in the 21st century.

Historical temperature trends, using data adjusted for inhomogeneities, were developed based on a procedure using the median of the slopes obtained from all possible combinations of two points in the series, which is less affected by extreme values, or outliers. Since annual precipitation amounts are considered normally distributed across North America, standard regression techniques were employed. Using a least squares method, historical precipitation trends were developed using quality controlled (non-homogenized) precipitation data. In both cases trends and confidence limits were computed at the 95% significance level unless otherwise specified.

Projected trends were developed principally for average maximum temperature (Tmax), average minimum temperature (Tmin), and total annual precipitation (Pcpn) for the three tri-decadal periods centred on the 2020's, 2050's, and the 2080's, by statistically downscaling the global output from the Canadian General Circulation Model (CGCM1) running the GHG + A1 emissions scenario, using the Statistical Downscaling Model (SDSM).

This study found that with respect to the base climate period (1961-90), projections at both sites over the next century are for annual average maximum temperatures to warm by as much as 5.4°C, annual average minimum temperatures to warm by as much as 3.8°C, and annual precipitation to increase by 10-15%. These site-specific projections are all in good agreement with the Intergovernmental Panel on Climate Change (IPCC) global projections.

Furthermore, the ratio in the Tmax to Tmin decadal temperature trends, which averaged 1.0 for Nova Scotia in the 20th century, is projected to increase to 2 by the 2020's, then diminish to 1.2 for the remaining two tri-decades of the 21st century.

It should be noted that downscaled scenarios used in this study were generated using only one GCM model running one emission scenario. Downscaled scenarios using other GCM models running different scenarios would likely produce somewhat different, but equally plausible, results.

PART I

Historical Record Analysis

Section One: Introduction

The Intergovernmental Panel on Climate Change (IPCC) concluded in their Third Assessment Report (IPCC, 2001): ''In light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations'. The global average temperature has risen by $0.6 \pm 0.2^{o}C$ over the 20th century. The 1990's was the warmest decade in the instrumental record (since 1861), and 1998 was the warmest year. The increase in global mean temperature has occurred mainly during two periods: from 1910 to 1945, and from 1976 to the present. In addition, the IPCC has concluded that the warming over the past 100 years is very unlikely to be due to natural, internal variability alone; and most of the warming over the past 50 years is likely due to the increase in greenhouse gas concentrations. The 20th century warming has also contributed significantly to the observed sea level rise, which has shown a global mean rise of 1.0 to 2.0 mm per year.

Unlike temperature, where a global average increase can be calculated, precipitation is examined on a continental basis. The IPCC reports that annual land precipitation has increased in the middle and high latitudes of the Northern Hemisphere since the publication of the previous assessment report in 1995/96. This very likely corresponds to a 0.5-1% increase per decade in the 20th century. The Southern Hemisphere has shown no systematic changes over that time.

The figures above are global or continental averages but no region on the globe experiences the global average. Each region has some unique climatology, and the experience of climate change and global warming in each region is also unique. The need to examine each region's climatology has given rise to the examination of local weather records to analyze historical trends specific to a given region.

This report examines the historical records of temperature and precipitation for two sites in Nova Scotia, Canada – Kentville and Greenwood. The sites are separated by a distance of 45 km and are both located in the Annapolis Valley region of Nova Scotia. Nova Scotia has a modified mid-latitude continental climate, with proximity to the coast and elevation determining local variation in climate. The climate of the Annapolis Valley is inland in character because of the shelter provided by the North and South Mountains, but is modified at either end by marine influences (Nova Scotia Museum of Natural History website). The main climatic features of the Valley are a warm, early spring, hot summers with less precipitation than elsewhere in the province, and a higher frequency of clear skies than in coastal areas. More specifically, in the Kentville and Greenwood areas, winters are cold but not severe (January mean daily temperature is about $-6^{o}C$). By July, the mean daily temperature is over $19^{o}C$. Total annual precipitation is 1100 to 1200 mm, and snowfall is moderate, less than 300cm (Canadian Climate Normals website).

Section Two: Data and Methodology

2.1 Data

This study focused on the two sites in the Annapolis Valley of Nova Scotia, the Kentville Canadian Department of Agriculture experimental farm and the Greenwood Airport, with data available from the Canadian Historical Climate Database (CHCD, website). The temperature measurements extracted from the CHCD were homogenized daily minimum and maximum temperature data; the precipitation amounts were measured daily precipitation data. The stations both reported at least 80% of their values for the periods of record.

The CHCD contains daily minimum, maximum and mean temperatures for 210 stations across Canada. These data have been adjusted for inhomogeneities (Vincent and Gullett, 1999) caused by non-climatic factors, such as station relocation and changes in observing practices, using a regression model technique. Monthly adjustment factors from previous work were interpolated to generate daily factors which were used to obtain the adjusted daily temperatures resulting in the reliable long term daily temperature data set used in this analysis. The Greenwood temperature record covered the period from 1943 to 1999, while the Kentville temperature record covered the period from 1914 to 1995.

The daily precipitation amounts were taken directly from the CHCD, with no additional adjustments to account for any non-climatic variability. The precipitation record for Greenwood contained information from 1943 to 2000, and the Kentville precipitation record contained information from 1914 to 2000. It should be noted that a change in instrumentation took place at the Kentville site mid-way through 1996. This did not appear to have caused a shift in the information with respect to the remainder of the record, although calculations may be influenced by the inclusion of this information. The highly variable and random nature of precipitation makes a determination of the effect of the new instrumentation difficult to determine quantitatively.

2.2 Methodology

The temperature record from Kentville was previously examined by Sutherland and Lines, as part of a study of regional temperature trends in Atlantic Canada (Sutherland and Lines, 2001). The temperature record for Greenwood was extracted and examined following the procedure used by Sutherland and Lines. Annual and seasonal averages were calculated from the daily minimum temperatures, daily maximum temperatures, and daily temperature ranges. The daily temperature ranges were not extracted from the CHCD, but calculated by subtracting the daily minimum temperature from the daily maximum temperature for each day over the entire record. The seasons were defined as follows: winter (December to February), spring (March to May), summer (June to August), and autumn (September to November). The annual and seasonal averages were then analysed for trend information.

The temperature trend analysis was based on a procedure using the median of the slopes obtained from all possible combinations of two points in the series (Zhang *et al.*, 2000). This estimator was used because it is less sensitive to the non-normality of the distribution and less affected by extreme values of outliers, compared to the least-squares estimate (Sen, 1968). The estimate of the error for the mean slope was calculated at the 95% level. The median slopes that fell in the range of the error of the estimate were considered to be significantly different from zero if the range of the error of the estimate was either all positive or all negative (i.e. if the error was smaller than the mean slope). Trends significant at levels other than 95% were noted where appropriate.

Unlike the temperature data, the precipitation data did not have an interdependent nature. In addition, annual precipitation amounts are considered normally distributed over most parts of Canada (Groisman and Easterling, 1994). Therefore, the precipitation trend analysis was carried out using least squares regression, with a calculated coefficient of determination (R^2) to indicate the closeness of the fit. Due to the random nature of precipitation, the values of the coefficient of determination were expected to be low. For the purposes of this report, a coefficient of determination (R^2) value above 0.1 was considered an acceptable fit for the trend line. The t-test was used to indicate the statistical significance of the trends. Trends were considered significant at the 95% level ($(1-P) \geq 0.95$), unless otherwise indicated.

Annual and seasonal sums and averages were produced and analysed for several variables, utilizing the daily precipitation information. Amounts of precipitation below 0.25mm were considered negligible, and those days were categorized as days with no precipitation for the purposes of the trend analysis. The total precipitation for a year or season was calculated by a summation of the daily precipitation amounts for that time period. A count of the number of days during a given time period with no precipitation (under 0.25mm) was done, as well as a count of the number of days with low precipitation amounts (between 0.30mm and 2.5mm), and the days with higher precipitation amounts (over 2.5mm). The average precipitation on a wet day was calculated by dividing the total precipitation for a time period by the total number of days that precipitation was received (sum of low and high precipitation days). The value for the extreme precipitation threshold was calculated as the 95th percentile of the daily precipitation amounts during the specified period, which corresponds to the highest 5% of precipitation amounts received on any day for that time period. All of these variables were analysed for the complete length of the available record. These variables were also analysed in approximately thirty-year sections, corresponding to periods of global warming and cooling over the past century (1914 to 1945, 1946 to 1975, 1976 to 2000).

A five-year moving average was calculated for the total annual precipitation. The moving average was calculated by finding the mean of the total precipitation for a five-year moving window, encompassing two years on either side of any given year. A linear least squares regression was then used to analyse for trends in the moving average. In addition, block means were calculated for five, ten and twenty-year sets of measurements. The five-year blocks started in 1915 for Kentville and 1945 for Greenwood, enabling a comparison of locations for the matching blocks. The ten-year and twenty-year blocks started in 1920 for Kentville and 1950 for Greenwood, again allowing for the same direct comparison of the blocks between sites. The twenty-year blocks overlapped with one another, the blocks for Kentville were defined as 1920-1939, 1930-1949, and continuing until the final block of 1980-1999.

Section Three: Historical Temperature Record - Results & Discussion

Graphical representation and further details of the analysis for this section are provided in Appendix A

3.1 Kentville 1914-1995

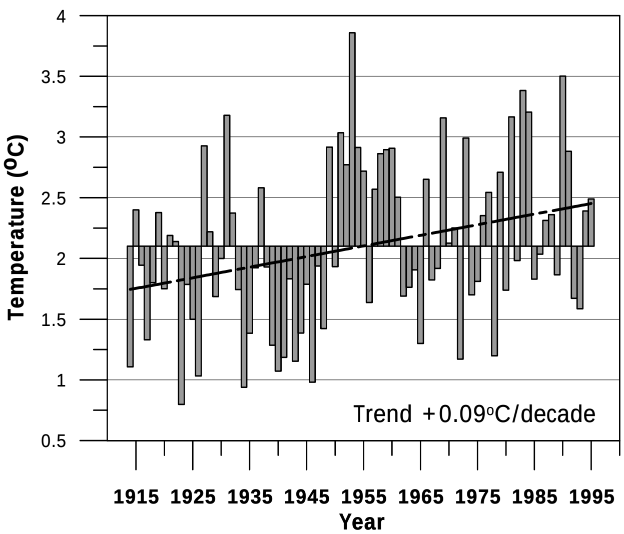

Figure I-1 Plot of average annual minimum temperatures in Kentville [baseline set at 2.1°C, average for entire record].

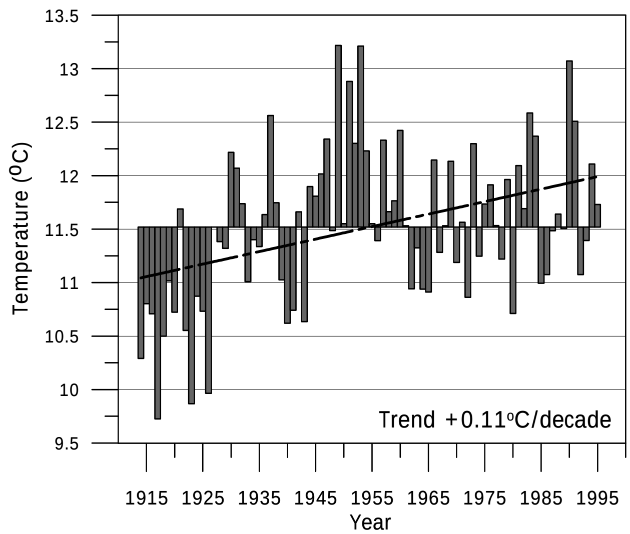

Figure I-2 Plot of average annual maximum temperatures in Kentville [baseline set at 11.5°C, average for entire record].

The annual minimum temperatures in Kentville demonstrated an increase in the latter half of the record versus the first half, corresponding to a shift in the early 1950's to warmer minimum temperatures, as shown in Figure I-1. The trend for the annual record indicated warming of almost 0.09°C per decade, as shown in Table I-1. Warming also occurred in each season, with the largest trend in summer. Only the annual and summer trends were significant at the 95% level.

The annual maximum temperature, displayed graphically in Figure I-2, also showed a warming trend, of a slightly higher magnitude, at 0.11°C per decade. The seasonal maximums also showed a worming trend, with the largest trend in winter (0.28°C/decade). The annual, spring and winter trends were significant at the 95% level.

As would be expected from the similarity of the magnitude of annual warming for the minimum and maximum temperatures, the daily temperature range over the entire year showed less change, although the increase was significant at the 95% level. The increase in the minimum temperature during the summer months led to a decrease in the daily temperature range for those months, while the increase in the maximum temperature during the spring and winter months increased the daily temperature range in these seasons. The trends were significant for the summer and winter seasons, and for the spring season at the 90% level.

Table I-1 Historic temperature trends for Kentville (1914-1995). Trends are the median change in degrees Celsius per decade; mean and error of estimate for mean are given (°C/decade).

	Average Minimum Temperature		Average Maximum Temperature		Average Daily Temperature Range	
	°C per decade	mean ± error	°C per decade	mean ± error	°C per decade	mean ± error
Annual	0.089	0.085 ± 0.058	0.110	0.130 ± 0.055	0.028	0.043 ± 0.035
Spring	0.100	0.083 ± 0.107	0.103	0.141 ± 0.109	0.033	0.057 ± 0.061
Summer	0.130	0.140 ± 0.076	0.012	0.048 ± 0.090	-0.126	-0.094 ± 0.077
Autumn	0.089	0.073 ± 0.081	0.037	0.053 ± 0.078	-0.035	-0.022 ± 0.067
Winter	0.035	0.049 ± 0.149	0.278	0.286 ± 0.126	0.235	0.235 ± 0.066

Corresponding graphs to the information in this table can be found in Appendix A — Graphs AK.01 through AK.15.

3.2 Greenwood 1943-1999

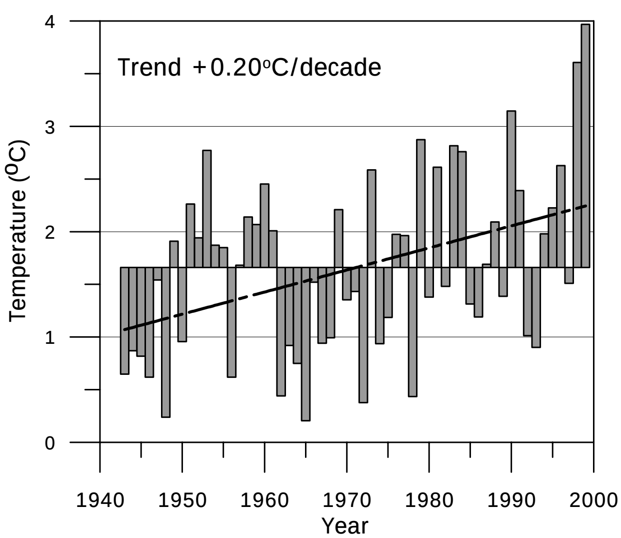

Figure I-3 Plot of average annual minimum temperatures in Greenwood [baseline set at 1.7°C,average for entire record].

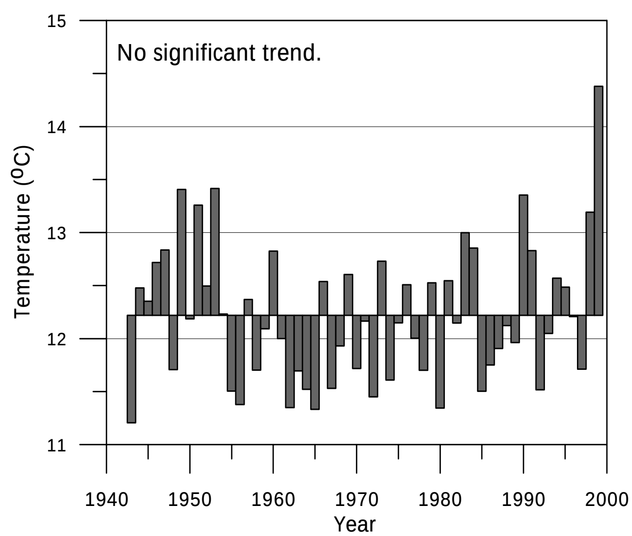

Figure I-4 Plot of average annual maximum temperatures in Greenwood [baseline set at 12.2°C,average for entire record].

The warming of the minimum temperatures for Greenwood demonstrated temperature increases above the global average. The average annual minimum temperatures, displayed in Figure I-3, increased in Greenwood by almost 0.2°C per decade. The trend values for Greenwood are given in Table I-2. Only the winter months did not show a significant trend of warming. The spring and summer months demonstrated warming trends of 0.25°C and 0.34°C per decade, respectively.

The maximum temperatures did not experience this obvious warming, as shown in Figure I-4. Annual maximum temperatures showed a slight warming trend, as with the spring, summer and winter months. The autumn months experienced a slight cooling over the record, although none of the trends were significant.

The daily temperature range demonstrated a strong narrowing for the annual range, based on the large increase in the minimum temperatures, as did the spring and summer. The autumn months also showed a significant decrease in the range of temperatures experienced, due to a decrease in the maximum temperatures along with the increase in the minimum temperatures.

Table I-2 Historic temperature trends for Greenwood (1943-1999). Trends are the median change in degrees Celsius per decade; mean and error of estimate for mean are given (°C/decade).

	Average Minimum Temperature		Average Maximum Temperature		Average Daily Temperature Range	
	°C per decade	mean ± error	°C per decade	mean ± error	°C per decade	mean ± error
Annual	0.198	0.253 ± 0.120	0.026	0.075 ± 0.097	-0.181	-0.178 ± 0.068
Spring	0.252	0.318 ± 0.183	0.122	0.150 ± 0.180	-0.144	-0.167 ± 0.115
Summer	0.338	0.346 ± 0.136	0.071	0.093 ± 0.139	-0.281	-0.254 ± 0.117
Autumn	0.185	0.167 ± 0.161	-0.131	-0.110 ± 0.140	-0.253	-0.277 ± 0.139
Winter	0.124	0.178 ± 0.237	0.101	0.172 ± 0.190	0.010	-0.008 ± 0.133

Corresponding graphs to the information in this table can be found in Appendix A — Graphs AG.01 through AG.15.

3.3 Spatial Variability

Overall, the warming of the minimum temperature in Greenwood was more pronounced than Kentville, and vice-versa for the maximum temperature. In comparing the two sites, the length of the record for each site must be taken into account. The Kentville measurements typically showed an increase in temperature around 1950. Unfortunately, the record for Greenwood only pre-dates this shift by seven years. A comparison of the means for the two periods in Kentville showed higher mean temperatures during the latter half of the record versus the early portion (see Table I-3).

The warmest years of the 1990's were the later years of the decade. The Kentville record does not include these years, as it ended in 1995. Inclusion of the information from the later years may increase the warming trend of the minimum temperature in Kentville to values that are closer in magnitude to the Greenwood warming.

Table I-3 Mean minimum and maximum temperatures in Kentville before and after 1950.

	Average Minimum Temperature (°C)		Average Maximum Temperature (°C)	
	mean for 1914-1950	mean for 1951-1995	mean for 1914-1950	mean for 1951-1995
Annual	1.78	2.36	11.25	11.73
Spring	-0.42	0.10	9.20	9.59
Summer	11.84	12.50	23.72	23.56
Autumn	4.34	4.80	13.51	13.67
Winter	-8.85	-8.10	-1.68	-0.06

Section Four: Historical Precipitation Record - Results & Discussion

Further graphical representations and details of analysis for this section are provided in Appendix B.

As would be intuitively expected from the weather we experience, precipitation varies greatly with time and geography. This poses great difficulty when examining the trends of an historical record of precipitation measurements.

4.1 Kentville 1914-2000

As stated earlier, the Kentville station had a change in instrumentation in mid-1996. A calculation of the historical trends discounting the information from the later years would be more accurate. Unfortunately, those latter years were the drier years over the last decade and not including them would leave a false impression of the precipitation trends in Kentville. A plot of the annual precipitation amounts showed no obvious shift in the measured amounts, especially when plotted with the corresponding amounts from Greenwood (Appendix B, Graph B.01).

Annual/Seasonal Precipitation Amounts, Extreme Precipitation and Average Amounts per Wet Day

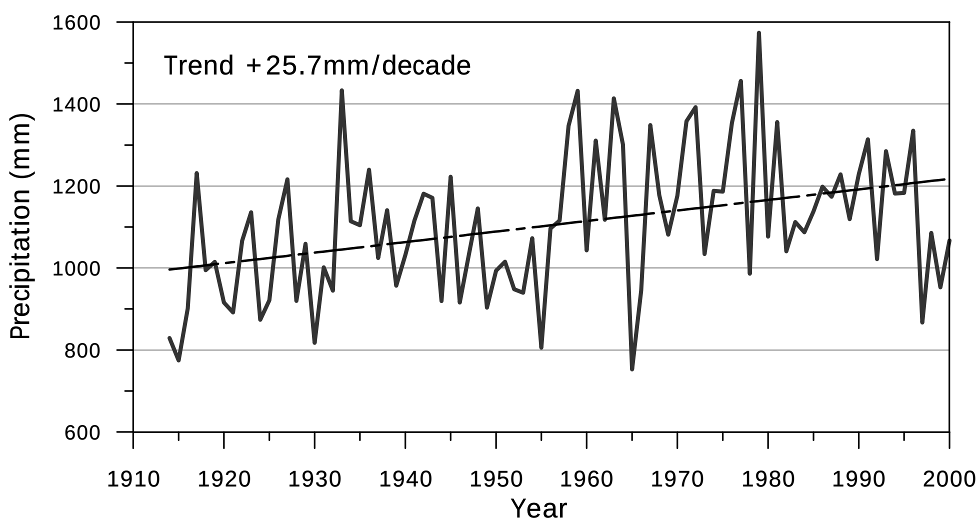

Figure I-5 Plot of annual precipitation amounts, in mm, versus year in Kentville over entire record. The linear least squares trend line is shown.

The annual precipitation amounts for Kentville demonstrated an increasing precipitation trend of 25.7mm per decade, as shown in Figure I-5. The coefficient of determination ($R^2 = 0.1416$), given in Table I-4, indicated an acceptable fit for precipitation. The summer and autumn precipitation amounts showed high variability, with no statistically significant trend for either season. The spring precipitation had an increase of 11.7mm per decade. The winter amounts showed an increase of 9.6mm per decade. The annual, spring and winter trends were all statistically significant.

Table I-4 Trend information for precipitation amounts, extreme precipitation thresholds and average precipitation per wet day in Kentville from 1914 to 2000. Trends given in mm/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Total Precipitation Amount			Extreme Precipitation Threshold (95th percentile)			Average Precipitation per Wet Day		
	mm per decade	R^2	1-P	mm per decade	R^2	1-P	mm per decade	R^2	1-P
Annual	25.71	0.1416	1.00	0.36	0.1009	1.00	0.05	0.0151	0.74
Spring	11.69	0.1719	1.00	0.68	0.1462	1.00	0.23	0.1513	1.00
Summer	-0.54	0.0004	0.14	-0.12	0.0040	0.44	-0.05	0.0045	0.46
Autumn	5.10	0.0183	0.79	0.31	0.0162	0.76	0.02	0.0005	0.16
Winter	9.59	0.1091	1.00	0.39	0.0701	0.99	0.00	0.0000	0.01

Corresponding graphs to information in this table can be found in Appendix B — Graphs B.01 through B.15.

The annual extreme precipitation showed a significant increase of almost 0.4mm per decade. As with the annual precipitation, the spring and winter thresholds also demonstrated significant trends, with a large increase during the spring months of almost 0.7mm per decade. The summer and autumn months demonstrated no significant trend.

The trend in the average amount of precipitation per wet day was not significant. The spring months showed an increase in the average amount per wet day of over 0.2mm per decade, which was statistically significant. The other seasons did not demonstrate significant trends for the average precipitation per wet day.

Number of Days with High, Low, and No Precipitation

The trends for the Kentville record are given in Table I-5. Annually, the number of days with low precipitation displayed an increasing trend of 2 days per decade, while the number of days with high precipitation amounts showed no significant trend. The number of days with no precipitation displayed a significant decrease of 2 days per decade.

Table I-5 Trend information for days with high precipitation amounts, low precipitation amounts and no precipitation in Kentville from 1914 to 2000. Trends given in days/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Days with High Precipitation (2.5mm and over)			Days with Low Precipitation (under 2.5mm)			Days with No Precipitation (under 0.25mm)		
	days per decade	R^2	1-P	days per decade	R^2	1-P	days per decade	R^2	1-P
Annual	0.53	0.0224	0.83	2.13	0.1775	1.00	-2.71	0.2385	1.00
Spring	0.39	0.0499	0.96	0.12	0.0037	0.42	-0.51	0.0401	0.94
Summer	-0.17	0.0106	0.66	0.52	0.0524	0.97	-0.35	0.0202	0.81
Autumn	0.20	0.0111	0.67	0.36	0.0358	0.92	-0.59	0.0460	0.95
Winter	0.13	0.0043	0.45	1.09	0.2991	1.00	-1.25	0.1744	1.00

Corresponding graphs to the information in this table can be found in Appendix B — Graphs B.16 through B.30

The seasonal trends showed some variability in the significance of the trends. The number of days in the spring with high precipitation showed a significant increasing trend of less than half a day per decade. There were more significant trends in the number of days with low precipitation, with an increase of just over half a day per decade in the summer and an increase of over one day in the winter. The autumn months also showed an increase of less than half a day, significant at the 90% level. The number of days with no precipitation also displayed several significant trends over the seasons. At the 95% level, the autumn months decreased by almost 0.6 days per decade, and the winter months decreased by 1.25 days per decade. The spring days with no precipitation also decreased, by slightly less than half a day, at the 90% significance level.

4.2 Greenwood 1943-2000

Annual/Seasonal Precipitation Amounts, Extreme Precipitation and Average Amounts per Wet Day

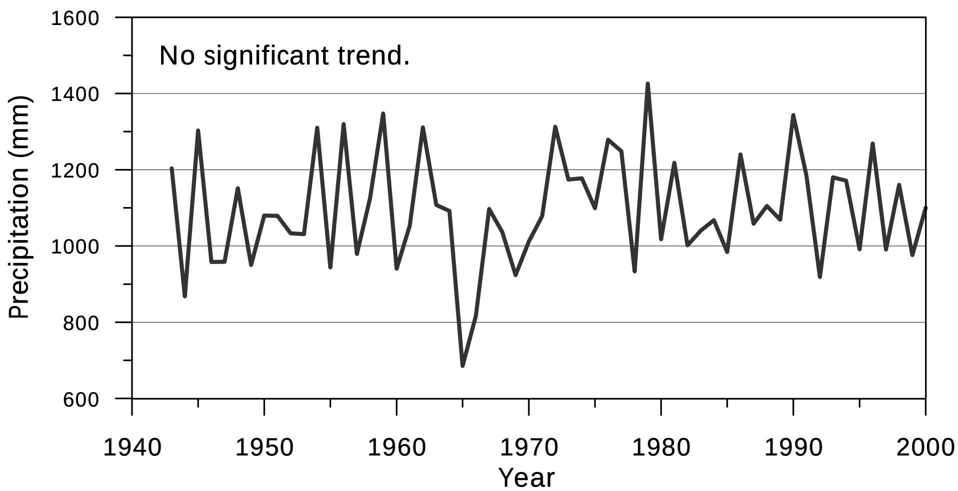

Figure I-6 Plot of annual precipitation amounts, in mm, versus year in Greenwood over entire record. The linear least squares trend was not significant.

The annual precipitation amounts and annual extreme precipitation threshold in Greenwood did not have significant trends. The annual average precipitation amount per wet day decreased by 0.1mm per decade, as given in Table I-6. The seasonal amounts displayed the same high degree of variability, with a few significant trends. The spring months had no significant trend for the three variables. The summer and winter season both demonstrated a significant decrease in the average amount of precipitation per wet day, decreasing by almost 0.4mm/decade and 0.2mm/decade, respectively. The autumn months were the only period that displayed a significant trend in the extreme precipitation threshold, increasing by 0.6mm/decade.

Number of Days with High, Low, and No Precipitation

The annual number of days with high precipitation demonstrated no significant trend in Greenwood, as shown in Table I-7. The number of days with low precipitation displayed a significant increase of 4.3 days/decade. This increase in the number of days with low precipitation is reflected in an almost identical decrease in the number of days with no precipitation, at 4.2 days/decade.

The seasonal trends in the number of days with varying amounts of precipitation displayed the same arrangement as the annual trends. The number of days with high precipitation showed no significant trend for any of the four seasons.

The number of days with low precipitation showed a significant increasing trend for all four seasons: 1.0 day/decade for spring, summer and autumn and 1.4 days/decade for winter. The number of days with no precipitation displayed the same trend as the annual trend for three of the four seasons, with a decrease of 1.3 days/decade for all three. The winter season showed no significant trend in the days with no precipitation.

Table I-6 Trend information for precipitation amounts, extreme precipitation thresholds and average precipitation per wet day in Greenwood from 1943-2000. Trends given in mm/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Total Precipitation Amount			Extreme Precipitation Threshold (95th percentile)			Average Precipitation per Wet Day		
	mm per decade	R^2	1-P	mm per decade	R^2	1-P	mm per decade	R^2	1-P
Annual	8.45	0.0094	0.53	0.23	0.0277	0.79	-0.11	0.0686	0.95
Spring	6.79	0.0326	0.82	0.43	0.0367	0.85	-0.01	0.0001	0.06
Summer	-1.20	0.0008	0.17	-0.13	0.0034	0.34	-0.36	0.1215	0.99
Autumn	10.94	0.0565	0.93	0.63	0.0648	0.95	0.03	0.0017	0.24
Winter	-5.85	0.0195	0.70	0.00	0.0000	0.00	-0.17	0.0845	0.97

Corresponding graphs to information in this table can be found in Appendix B — Graphs B.01 through B.15.

Table I-7 Trend information for days with high precipitation amounts, low precipitation amounts and no precipitation in Greenwood from 1943 to 2000. Trends given in days/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Days with High Precipitation (2.5mm and over)			Days with Low Precipitation (under 2.5mm)			Days with No Precipitation (under 0.25mm)		
	days per decade	R^2	1-P	days per decade	R^2	1-P	days per decade	R^2	1-P
Annual	-1.60	0.0008	0.16	4.30	0.4053	1.00	-4.15	0.2365	1.00
Spring	0.25	0.0104	0.55	1.01	0.1452	1.00	-1.27	0.1230	0.99
Summer	0.29	0.0156	0.65	1.04	0.2774	1.00	-1.33	0.1652	1.00
Autumn	0.28	0.0096	0.54	0.99	0.2174	1.00	-1.27	0.1167	0.99
Winter	-0.79	0.0598	0.94	1.43	0.2207	1.00	-0.10	0.0006	0.15

Corresponding graphs to information in this table can be found in Appendix B — Graphs B.16 through B.30

4.3 Comparison of Mean Values for Kentville and Greenwood

It is interesting to note the difference in seasonal means of the extreme precipitation and average precipitation on a wet day (see Table I-8 and Table I-9). For both sites, the summer months received the lowest average amount of precipitation, and the winter months received the highest average amount, both with a difference between the two means of around 90mm.

The summer months in Kentville averaged almost an identical amount of precipitation on a wet day as the winter months, with a lower extreme precipitation threshold. The summer months in Kentville received their precipitation over fewer days than the winter months, in order to have the large difference in amount of precipitation with a similar average amount per day. There were, on average, 59 dry days during the summer months and only 43 dry days during the winter months. The mean extreme precipitation threshold for the summer months was lower than the winter months as well, possibly indicating fewer occurrences of heavy precipitation in the summer months

Table I-8 Seasonal Means of Total Precipitation Amounts, Extreme Precipitation Threshold, and Average Precipitation per Wet Day for entire Kentville record (1914-2000).

Season	Total Precipitation Amount	Extreme Precipitation Threshold (95th percentile)	Average Precipitation per Wet Day
Spring	248.85mm	14.32mm	6.41mm
Summer	232.73mm	13.65mm	7.16mm
Autumn	301.32mm	17.77mm	7.90mm
Winter	323.18mm	17.42mm	7.19mm

The summer months in Greenwood averaged a higher amount of precipitation on a wet day than the winter months. In contrast to the Kentville information, this indicated heavier precipitation on a wet day in the summer months, with fewer dry days during the winter months. The mean number of dry days in the winter months in Greenwood was almost 36, compared to 60 dry days during the summer months.

Table I-9 Seasonal Means of Total Precipitation Amounts, Extreme Precipitation Threshold and Average Precipitation per Wet Day for entire Greenwood record (1943-2000).

Season	Total Precipitation Amount	Extreme Precipitation Threshold (95th percentile)	Average Precipitation per Wet Day
Spring	245.94mm	13.39mm	5.94mm
Summer	239.26mm	14.15mm	7.49mm
Autumn	290.33mm	16.82mm	7.43mm
Winter	332.66mm	16.64mm	6.16mm

4.4 Moving Averages and Block Mean

The five-year moving average plots for the annual precipitation amounts in Kentville and Greenwood are shown in Figure I-7. The trend analysis for the Kentville moving average exhibited an increasing trend of 25.4mm per decade. This is close to the annual trend demonstrated earlier (25.7mm/decade). The fit of the moving average trend was better, with a coefficient of determination (R^2) of 0.3944 versus the 0.1416 of the original measurements. The Greenwood moving average showed some improvement in the fit of the linear trend, the trend was statistically significant at an increase of 10.2mm/decade. The seasonal moving average trends, given in Table I-10, were all statistically significant with the exception of the summer months for both locations. All of the seasons in Kentville displayed an increase in the precipitation amounts. For Greenwood, the trend directions were mixed. The spring and autumn months increased, while the winter months decreased.

Table I-10 Trend information for five-year moving averages of annual and seasonal precipitation amounts in Kentville and Greenwood. Trends were calculated by linear least squares regression and are given in mm per decade.

Season	Kentville			Greenwood		
	mm/decade	R^2	1-P	mm/decade	R^2	1-P
Annual	25.37	0.3944	1.00	10.24	0.0705	0.95
Spring	11.66	0.5320	1.00	6.90	0.2136	1.00
Summer	-0.57	0.0020	0.32	1.75	0.0067	0.45
Autumn	4.97	0.0631	0.98	11.81	0.2592	1.00
Winter	9.61	0.2846	1.00	-8.69	0.1387	1.00

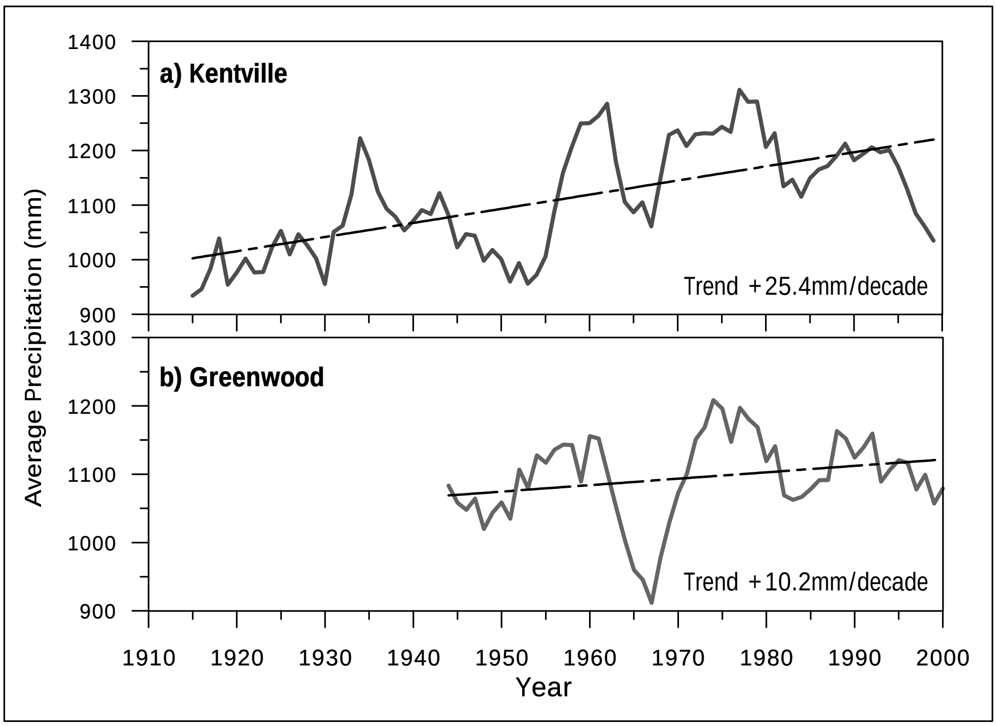

Figure I-7 Plot of five-year moving average of annual precipitation amounts versus year for **a)** Kentville and **b)** Greenwood. Linear least squares for regression lines and trends are given for each site.

The five-year block means are shown for both sites in Figure I-8. The earlier blocks do not show the same trend when comparing the two locations. The ten-year blocks do not follow a similar trend for the two locations, and the twenty-year blocks show some similarity but not a continuous trend over the blocks available.

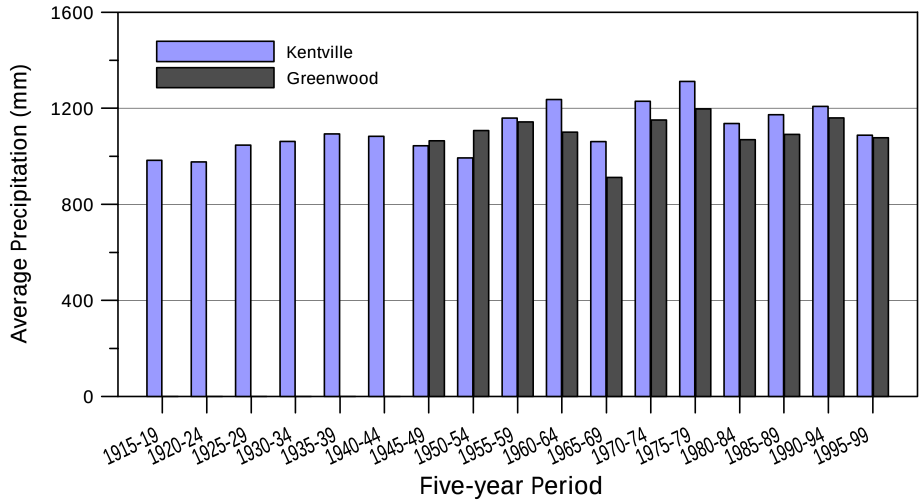

Figure I-8 Five-year block means of total precipitation amounts for Kentville and Greenwood.

Section Five: Sub-periods of Historical Precipitation Record - Results & Discussion

Further graphical representations and details of analysis for this section are provided in Appendix C.

As mentioned earlier, there have been two periods of warming and one period of cooling globally over the past century. The first period of warming occurred between 1910 and 1945, the cooling period between 1946 and 1975, and the second warming period between 1976 and the present. These periods corresponded to approximately thirty-year sections for the Kentville and Greenwood climate records. Each record was sub-divided to examine the impact of these periods on precipitation characteristics.

5.1 1914 to 1945

The Kentville location was the only one of the two Valley locations with data for this period. The trends for precipitation amounts, extreme precipitation thresholds and average precipitation on a wet day are given in Table I-11. The total precipitation annually showed an increasing trend of 66.8mm per decade, a much higher amount than the trend for the entire record. The spring and autumn months also showed higher trends (at 90% confidence level) for seasonal precipitation, at 20.5mm/decade and 33.5mm/decade, respectively. The summer and winter months showed no significant trend. The extreme precipitation and average precipitation per wet day showed no significant trends for the annual or seasonal records.

Table I-11 Trend information for precipitation amounts, extreme precipitation thresholds and average precipitation per wet day in Kentville from 1914 to 1945. Trends given in mm/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Total Precipitation Amount			Extreme Precipitation Threshold (95th percentile)			Average Precipitation per Wet Day		
	mm per decade	R^2	1-P	mm per decade	R^2	1-P	mm per decade	R^2	1-P
Annual	66.79	0.1771	0.98	0.54	0.0507	0.78	0.19	0.0347	0.69
Spring	20.54	0.1156	0.94	0.85	0.0618	0.83	0.29	0.0570	0.81
Summer	5.77	0.0051	0.30	0.51	0.0099	0.41	0.51	0.0812	0.89
Autumn	33.53	0.1025	0.93	1.06	0.0307	0.66	0.41	0.0253	0.62
Winter	6.72	0.0169	0.52	-0.06	0.0003	0.07	-0.34	0.0416	0.74

Corresponding graphs for the information in this table can be found in Appendix C — Graphs CK.01 through CK.10.

The trends for the number of days with high, low and no precipitation are given in Table I-12. The annual record showed a strong increasing trend in the number of days with high precipitation of 4.6 days/decade, and a decreasing trend of 5.2 days/decade in the number of days with no precipitation. The seasonal trends were not as clear. The spring months and the summer months showed no significant trends for these three variables. The autumn months followed along the annual trends, with an increase of 2.9 days per decade in the number of days with high precipitation and a decrease of 2.3 days per decade in the number of days with no precipitation. The winter months displayed a similar decrease in the number of days with no precipitation at 2.9 days per decade but showed a significant trend in the number of days with low precipitation, an increase of 1.9 days.

Table I-12 Trend information for days with high precipitation amounts, low precipitation amounts and no precipitation in Kentville from 1914 to 1945. Trends given in days/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Days with High Precipitation (2.5mm and over)			Days with Low Precipitation (under 2.5mm)			Days with No Precipitation (under 0.25mm)		
	days per decade	R^2	1-P	days per decade	R^2	1-P	days per decade	R^2	1-P
Annual	4.55	0.2680	1.00	0.61	0.0035	0.25	-5.16	0.1735	0.98
Spring	1.26	0.0869	0.90	0.20	0.0019	0.19	-1.46	0.0624	0.83
Summer	-0.44	0.0091	0.40	-1.02	0.0598	0.82	1.46	0.0534	0.80
Autumn	2.89	0.2756	1.00	-0.64	0.0207	0.57	-2.25	0.1604	0.98
Winter	0.96	0.0627	0.83	1.92	0.1459	0.97	-2.88	0.2138	0.99

Corresponding graphs for the information in this table can be found in Appendix C – Graphs CK.11 through CK.25.

5.2 1946 to 1975

Kentville

There were several significant annual trends in Kentville for the period from 1946 to 1975. The annual precipitation amounts exhibited a large increase, of 89.1mm/decade, as shown in Table I-13. The extreme precipitation threshold also demonstrated an increasing trend of 2.1mm/decade, and the average precipitation per wet day increased by 0.7mm/decade. There was a decrease of 2.5 days per decade in the number of days with low precipitation (Table I-14), which was significant at the 90% level.

Table I-13 Trend information for precipitation amounts, extreme precipitation thresholds and average precipitation per wet day in Kentville from 1946 to 1975. Trends given in mm/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Total Precipitation Amount			Extreme Precipitation Threshold (95^{th} percentile)			Average Precipitation per Wet Day		
	mm per decade	R^2	1-P	mm per decade	R^2	1-P	mm per decade	R^2	1-P
Annual	89.08	0.1836	0.98	2.07	0.3324	1.00	0.67	0.3441	1.00
Spring	21.16	0.0820	0.87	2.17	0.1715	0.98	0.54	0.1147	0.93
Summer	7.93	0.0116	0.43	0.87	0.0465	0.75	0.40	0.0459	0.74
Autumn	49.64	0.2082	0.99	4.47	0.3622	1.00	1.28	0.3072	1.00
Winter	10.12	0.0171	0.51	1.43	0.1436	0.96	0.42	0.1281	0.95

Corresponding graphs for the information in this table can be found in Appendix C – Graphs CK.01 through CK.10.

The spring months in Kentville displayed trends in two categories, a significant increase in extreme precipitation threshold of 2.2mm/decade and an increase in the average precipitation on a wet day of 0.5mm/decade (significant at the 90% level). The summer months displayed a decrease of 1.7 days/decade with low precipitation, with none of the other properties demonstrating any significant trend. The autumn months exhibited significant trends in the measured precipitation properties: an increase of 49.6mm/decade in the seasonal precipitation, an increase of 4.5mm/decade in the extreme precipitation threshold, and an increase of 1.3mm/decade in the average precipitation on a wet day. The winter months demonstrated significant trends in two properties: an increase in the extreme precipitation threshold of 1.4mm/decade and an increase of 0.4mm/decade in the average precipitation per wet day (at almost the 95% significance level).

Table I-14 Trend information for days with high precipitation amounts, low precipitation amounts and no precipitation in Kentville from 1946 to 1975. Trends given in days/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Days with High Precipitation (2.5mm and over)			Days with Low Precipitation (under 2.5mm)			Days with No Precipitation (under 0.25mm)		
	days per decade	R^2	1-P	days per decade	R^2	1-P	days per decade	R^2	1-P
Annual	0.05	0.0000	0.02	-2.46	0.1070	0.92	1.99	0.0193	0.54
Spring	0.22	0.0025	0.21	-0.52	0.0149	0.48	0.30	0.0024	0.20
Summer	0.87	0.0333	0.67	-1.71	0.1787	0.98	0.85	0.0235	0.58
Autumn	0.68	0.0198	0.54	-0.61	0.0352	0.68	-0.28	0.0017	0.17
Winter	-1.46	0.0547	0.79	0.25	0.0038	0.25	1.01	0.0160	0.49

Corresponding graphs for the information in this table can be found in Appendix C — Graphs CK.11 through CK.25.

Greenwood

The Greenwood location exhibited several strong trends over this period, given in Table I-15 and Table I-16. The annual number of days with low precipitation increased by 9.4 days/decade, with a decrease of 7.2 days/decade in the number of days with no precipitation. No significant trends were observed in the other properties on an annual basis.

Table I-15 Trend information for precipitation amounts, extreme precipitation thresholds and average precipitation per wet day in Greenwood from 1946 to 1975. Trends given in mm/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Total Precipitation Amount			Extreme Precipitation Threshold (95^{th} percentile)			Average Precipitation per Wet Day		
	mm per decade	R^2	1-P	mm per decade	R^2	1-P	mm per decade	R^2	1-P
Annual	14.76	0.0073	0.35	0.61	0.0661	0.83	-0.21	0.0805	0.87
Spring	-2.24	0.0013	0.15	-0.03	0.0001	0.03	-0.30	0.0566	0.79
Summer	9.28	0.0141	0.47	0.83	0.0574	0.80	-0.23	0.0145	0.47
Autumn	30.61	0.1202	0.94	2.10	0.1916	0.98	0.34	0.0422	0.72
Winter	-23.78	0.0885	0.89	-0.28	0.0053	0.30	-0.59	0.2546	1.00

Corresponding graphs for the information in this table can be found in Appendix C — Graphs CG.01 through CG.10.

The spring months demonstrated a significant trend solely in the number of days with low precipitation, with an increase of 2.0 days/decade. The summer months demonstrated no significant trends at the 95% level but an increasing trend of 1.1 days/decade in the number of days with low precipitation was significant at the 90% level. The autumn months exhibited trends in several other properties: an increase in seasonal precipitation of 30.6mm/decade (significant at the 90% level), an increase in the extreme precipitation threshold of 2.1mm/decade, an increase of 2.2 days/decade with low precipitation and a decrease of 2.3 days/decade with no precipitation. The winter months also showed significant trends in several properties: a decrease in the average precipitation per wet day of 0.6mm/decade, a decrease of 2.9 days/decade with high precipitation, and an increase of 3.9 days/decade with low precipitation.

Table I-16 Trend information for days with high precipitation amounts, low precipitation amounts and no precipitation in Greenwood from 1946 to 1975. Trends given in days/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Days with High Precipitation (2.5mm and over)			Days with Low Precipitation (under 2.5mm)			Days with No Precipitation (under 0.25mm)		
	days per decade	R^2	1-P	days per decade	R^2	1-P	days per decade	R^2	1-P
Annual	-2.17	0.0313	0.65	9.37	0.5118	1.00	-7.21	0.1943	0.99
Spring	-0.10	0.0004	0.09	1.97	0.1465	0.96	-1.87	0.0719	0.85
Summer	0.60	0.0168	0.50	1.09	0.1070	0.92	-1.69	0.0784	0.87
Autumn	0.07	0.0002	0.06	2.18	0.3423	1.00	-2.25	0.1493	0.97
Winter	-2.86	0.2178	0.99	3.94	0.4327	1.00	-1.10	0.0172	0.51

Corresponding graphs for the information in this table can be found in Appendix C — Graphs CG.11 through CG.25.

5.3 1976 to 2000

Kentville

The last of the three approximately thirty-year periods contained the driest and warmest years of the century, the 1990's. The significant trends in the Kentville record over this period, given in Table I-17 and Table I-18, were numerous. A large decrease, of 88.6mm/decade, was demonstrated for the total annual precipitation, while the extreme precipitation decreased by 1.8mm/decade and the average precipitation on a wet day decreased by 1.0mm/decade. These decreases opposed the trends of the other two periods, where these properties increased or showed no trend. The number of days with high precipitation and the number of days with no precipitation decreased by 4.6 days/decade and 11.4 days/decade, respectively. The number of days with low precipitation increased by 16.0 days/decade. Once again, this revealed an opposite trend to the other periods.

Unlike the annual trends, the seasonal trends in Kentville were not significant across all the properties. The spring months exhibited a trend only in the number of days with low precipitation, increasing by 3.6 days/decade, significant at the 90% level. The summer months demonstrated significant trends in all of the properties, as with the annual analysis. The summer months followed the same direction as the annual trends. The seasonal precipitation for summer exhibited a decreasing trend of 59.4mm/decade, the extreme precipitation decreased by 4.8mm/decade and the average precipitation per wet day decreased by 2.2mm/decade. The number of days with high precipitation decreased by 2.6 days/decade, the days with no precipitation decreased by 4.1 days/decade (90% level) and the days with low precipitation increased by 6.7 days/decade. The autumn months exhibited significant trends in the number of days with low precipitation, increasing by 4.9 days/decade, and the number of days with no precipitation, decreasing by 5.8

days/decade. The winter months indicated significant decreases in the total seasonal precipitation of 45.6mm/decade and in the average precipitation per wet day of 0.8mm/decade.

Table I-17 Trend information for precipitation amounts, extreme precipitation thresholds and average precipitation per wet day in Kentville from 1976 to 2000. Trends given in mm/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Total Precipitation Amount			Extreme Precipitation Threshold (95th percentile)			Average Precipitation per Wet Day		
	mm per decade	R^2	1-P	mm per decade	R^2	1-P	mm per decade	R^2	1-P
Annual	-88.59	0.1611	0.95	-1.83	0.2119	0.98	-0.97	0.4580	1.00
Spring	-11.61	0.0116	0.39	-1.02	0.0234	0.53	-0.42	0.0313	0.60
Summer	-59.39	0.3181	1.00	-4.82	0.3575	1.00	-2.22	0.5152	1.00
Autumn	27.27	0.0469	0.70	2.56	0.0813	0.83	-0.20	0.0082	0.33
Winter	-45.60	0.1578	0.95	-1.87	0.1059	0.89	-0.82	0.2175	0.98

Corresponding graphs for the information in this table can be found in Appendix C — Graphs CK.01 through CK.10.

Table I-18 Trend information for days with high precipitation amounts, low precipitation amounts and no precipitation in Kentville from 1976 to 2000. Trends given in days/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Days with High Precipitation (2.5mm and over)			Days with Low Precipitation (under 2.5mm)			Days with No Precipitation (under 0.25mm)		
	days per decade	R^2	1-P	days per decade	R^2	1-P	days per decade	R^2	1-P
Annual	-4.55	0.1684	0.96	16.00	0.4369	1.00	-11.45	0.3664	1.00
Spring	-1.79	0.0720	0.81	3.62	0.1339	0.93	-1.82	0.0257	0.56
Summer	-2.60	0.2140	0.98	6.72	0.3144	1.00	-4.12	0.1467	0.94
Autumn	0.86	0.0167	0.46	4.92	0.2639	0.99	-5.78	0.1985	0.97
Winter	-1.14	0.0319	0.61	0.64	0.0103	0.37	0.50	0.0027	0.20

Corresponding graphs for the information in this table can be found in Appendix C — Graphs CK.11 through CK.25.

Greenwood

The Greenwood record for this period exhibited far fewer significant trends (Table I-19 and I-20) than the Kentville record, and only for the summer season. The total summer precipitation decreased by 54.6mm/decade, the extreme precipitation threshold decreased by 3.0mm/decade, and the average precipitation on a wet day decreased by 1.3mm/decade. The number of days with high precipitation also displayed a decreasing trend of 1.9 days/decade. These trends followed the same direction as the Kentville trends.

Table I-19 Trend information for precipitation amounts, extreme precipitation thresholds and average precipitation per wet day in Greenwood from 1976 to 2000. Trends given in mm/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Total Precipitation Amount			Extreme Precipitation Threshold (95th percentile)			Average Precipitation per Wet Day		
	mm per decade	R^2	1-P	mm per decade	R^2	1-P	mm per decade	R^2	1-P
Annual	-33.96	0.0347	0.63	-0.29	0.0068	0.30	-0.20	0.0461	0.70
Spring	7.55	0.0060	0.29	1.27	0.0426	0.68	0.04	0.0004	0.07
Summer	-54.58	0.4108	1.00	-2.96	0.2650	0.99	-1.33	0.4726	1.00
Autumn	18.97	0.0315	0.60	0.78	0.0216	0.52	0.15	0.0089	0.35
Winter	-9.09	0.0123	0.40	-0.95	0.0337	0.62	0.00	0.0000	0.01

Corresponding graphs for the information in this table can be found in Appendix C – Graphs CG.01 through CG.10.

Table I-20 Trend information for days with high precipitation amounts, low precipitation amounts and no precipitation in Greenwood from 1976 to 2000. Trends given in days/decade, with R^2 values to indicate the closeness of fit, and (1-p) values indicating statistical significance.

	Days with High Precipitation (2.5mm and over)			Days with Low Precipitation (under 2.5mm)			Days with No Precipitation (under 0.25mm)		
	days per decade	R^2	1-P	days per decade	R^2	1-P	days per decade	R^2	1-P
Annual	-1.97	0.0319	0.61	2.71	0.0508	0.72	-0.79	0.0025	0.19
Spring	-0.38	0.0046	0.25	1.46	0.0651	0.78	-1.08	0.0214	0.51
Summer	-1.94	0.2007	0.98	0.68	0.0298	0.59	1.26	0.0436	0.68
Autumn	0.78	0.0115	0.39	1.18	0.0572	0.75	-1.95	0.0412	0.67
Winter	-0.54	0.0066	0.30	-0.67	0.0134	0.42	1.15	0.0170	0.47

Corresponding graphs for the information in this table can be found in Appendix C – Graphs CG.11 through CG.25.

5.4 Comparison of Periods

Overall, the precipitation characteristics demonstrated a marked difference in the trend between the periods. For the Kentville record, the two earlier periods typically showed similar trends, some in magnitude and most in direction, while the later period (1976-2000) demonstrated either a larger magnitude of change or a reversal of direction of the trend. The Greenwood record indicated a similar shift between the two most recent periods. The first two periods were wetter in Kentville, with increasing precipitation over the period when a trend was observed. The most recent period was drier for both locations, with decreasing amounts of precipitation, especially during the summer months.

Section Six: Summaries & Conclusions for Historical Record Analysis

6.1 Summary of Temperature Records

Results and discussion presented in Section Three.

Overall, the temperatures in Kentville became warmer over the period of record (1914-1995), reflecting the warming evident globally. In the summer and autumn, this was evidenced in higher minimum temperatures, while in the spring and winter, it was evidenced in higher maximum temperatures. Specifically, the annual average minimum and maximum temperatures each increased, by 0.09°C and 0.11°C per decade, respectively. The average minimum temperature in the summer increased, by 0.13°C/decade, and in the autumn, by 0.09°C/decade (90% significance level). The average maximum temperature increased in the other two seasons, a spring increase of 0.10°C/decade and a winter increase of 0.28°C/decade. The large increase in the maximum temperature during the winter increased the average daily temperature range as well.

The temperature changes in Greenwood over the period of record (1943-1999) revealed a trend of days that were less cold, with increases in average minimum temperatures, instead of warmer days, which would be reflected in higher average maximum temperatures. Specifically, the annual average minimum temperature increased by 0.20°C/decade. The individual seasonal increases, where significant, were similar or slightly larger than the overall annual increase. The spring increase was 0.25°C/decade, summer was 0.34°C/decade, and autumn was 0.19°C/decade. The winter months had the sole increase in the average maximum temperature (90% significance level) of 0.10°C/decade

6.2 Summary for Entire Precipitation Records

Results and discussion presented in Section Four.

Over the entire precipitation record in Kentville (1914-2000), several trends were evident. On an annual basis, there was an increase in the amount of precipitation received and an increase in the extreme precipitation threshold, reflected seasonally in the spring and winter months. There was also an increase in the number of days during the year with low precipitation amounts and a decrease in the number of days with no precipitation. Seasonally, these trends were displayed to some extent over all four seasons. The spring months displayed the decrease in 'dry' days, the summer months an increase in the low precipitation days, and the autumn and winter months showed both the increase in low precipitation days and decrease in dry days. The spring months displayed the lone significant change (an increase) in the number of days with high precipitation amounts. These trends indicated that the increase in precipitation amounts came as heavier precipitation during extreme events, with an increase in the number of events only occurring in the spring. The additional precipitation was also received as more frequent days with low precipitation amounts.

The precipitation trends over the entire record in Greenwood (1943-2000) varied from the Kentville record. The total precipitation amounts showed no significant changes, with the exception of an increase in the autumn months (90% significance level). Annually, the average precipitation per wet day decreased in Greenwood, reflected seasonally in the summer and winter months. The extreme precipitation threshold increased in the autumn months. The distribution of precipitation changed over the entire record, with an annual increase in the number of days with low precipitation amounts and a decrease in the number of days with no precipitation. Kentville displayed this same combination of trends. Over the seasons, this increase/decrease combination appeared in the spring, summer, and autumn months. The winter months had an increase in the number of days with low precipitation but the decrease appeared in the number of days with high precipitation, rather than the days with no precipitation. The trends in Greenwood indicated a shift in the pattern of precipitation, with little or no change in the amount of precipitation. An increase in the number of days with low precipitation and decrease in dry days led to a decrease in the average precipitation per wet day. The increase in amount of precipitation in the autumn months and corresponding increase in the extreme precipitation indicated increased precipitation during extreme events, with no increase in their frequency.

6.3 Summary for Precipitation Record Sub-periods

Results and discussion presented in Section Five.

1914 to 1945

There were limited significant trends for this first period at the Kentville site. The total precipitation increased annually, with an increased number of days with heavy precipitation and fewer days with no precipitation. The spring and autumn months had increased precipitation amounts (at 90% significance level). The spring and summer months displayed no trends in the distribution of precipitation. The autumn months displayed the same increase in days with heavy precipitation and decrease in days with no precipitation. The winter months displayed the same decrease in 'dry days' but increased in the days with low precipitation.

1946 to 1975

The climate changes for the two sites over this period varied. In Kentville, the total precipitation amounts increased significantly over the year, mainly in the spring and autumn months. The extreme precipitation threshold and average precipitation per wet day also increased, again in the spring and autumn months along with the winter months. The distribution of precipitation showed little significant change over the period. There was an annual increase in the number of days with low precipitation, exhibited seasonally during the summer months.

In Greenwood, the trends for the period occurred mainly in the distribution of precipitation, rather than in the amounts. Annually, there was an increase in the number of days with low precipitation and a corresponding decrease in the number of days with no precipitation. The spring and summer months both had increases in the number of days with low precipitation. There was an increase in the total precipitation amount and the extreme precipitation threshold during the autumn months, as well as the same increase/decrease scenario for the days with low precipitation and days with no precipitation. The increase in the extreme precipitation threshold and not in the number of days with high precipitation amounts indicated an increase in the amount of precipitation during an extreme event, but not an increase in the number of extreme events. The winter months had a decrease in the average precipitation per wet day, in conjunction with a decrease in the number of days with high precipitation amounts and an increase in the number of days with low precipitation, implying more frequent precipitation with fewer extreme events.

1976 to 2000

The number of significant trends in Kentville for this period was rather surprising, when compared with the other periods. The trends all showed a decreasing amount of precipitation, especially in the summer months. There was also a shift in the distribution of the precipitation over the period. The number of days with high precipitation and no precipitation decreased and the number of days with low precipitation increased. These changes, when considered with the decreases in the other three variables, implied fewer days with heavy precipitation, and less precipitation on those heavy days. The summer months reflected these annual changes for every variable. The other seasons were less obvious, with only a few trends for each. The spring months increased in the number of days with low precipitation, the autumn months also increased in the number of days with low precipitation but also decreased in the number of days with no precipitation. These trends would indicate an overall wetter spring and autumn, with more frequent precipitation but no increased amounts. The winter months decreased in the amount of precipitation and the average precipitation per wet day. These trends, taken with the lack of changes in the distribution of precipitation, implied less precipitation on a wet day with the same number of wet days over the season.

The trends in Greenwood appeared for the summer months. The trends were similar to those in Kentville, with a decreasing amount of precipitation, a decreasing extreme precipitation threshold and a decreasing average amount of precipitation per wet day. There was also a decrease in the number of days with high precipitation amounts. Taken together, the summers in Greenwood became drier through the period, with a decrease in the amount of precipitation received, and no changes in the frequency of precipitation.

6.4 Conclusions

The temperatures in Kentville and Greenwood warmed over the period examined in this report. The average minimum and maximum temperatures in Kentville both increased, while in Greenwood the increases were in the average minimum temperatures. The annual warming trend in these parameters was between 0.09°C and 0.2°C per decade for the sites, with higher warming evidenced over several of the seasons.

The precipitation increased over the entire record in Kentville, with no increase in Greenwood over its entire record. This increase in Kentville was accompanied by a shift in the precipitation pattern, with an increase in the number of days with low precipitation amounts and a decrease in the number of days with no precipitation. Greenwood displayed the same shift in precipitation, with no increase in precipitation amounts. When the records were split into sub-periods, a different picture emerged. In general, there was increasing precipitation over the first two sub-periods of 1914-1945 (Kentville only) and 1946-1975. The third, and most recent, sub-period of 1976-2000 displayed a decrease in the amount of precipitation in Kentville, with lower amounts of precipitation received on days with heavy precipitation and fewer days with heavy precipitation. There was an increase in the number of days with lower precipitation and a decrease in the number of days with no precipitation. The latest sub-period in Greenwood displayed no annual trends, but the same decrease in precipitation amounts, decrease in frequency of days with heavy precipitation, and less precipitation on those days was displayed for the summer months in Greenwood.

PART II

PLAUSIBLE FUTURE CLIMATE SCENARIO

Section One: Data and Methodology

1.1 Model and Data Overview

The prediction of future climates has been done primarily on a global scale. Global averages for temperature are often quoted. Future estimates for precipitation, which are more difficult to predict, are often examined on a continental scale. The Global Climate Models (GCM's) predict plausible future climates on a global scale, as their title implies. A grid is placed over the surface of the globe and the area falling inside the box formed by the grid is treated as a single entity. The grid boxes each span 300km x 400km. More often than not, the local impacts are lost in the coarse spatial scale of these models, making prediction of impacts on a specific region difficult.

The global climate model used to generate large-scale scenarios in this study was from the Canadian Climate Centre for Modelling and Analysis (CCCma) (CCCma website), specifically the first version of the Canadian Coupled General Circulation Model (CGCM1). All predictor variables were prepared and made available by the Canadian Climate Impacts Scenario (CCIS) Project (CCIS website).

The predictor sets were generated for three future periods: 2011 to 2040, 2041 to 2070, and 2071 to 2100. They were generated in the form of daily data from the CGCM1 "GHG + A1" experiment, normalized with respect to 1961 to 1990. The predictors ranged from basic variables, such as mean temperature and mean sea level pressure, to calculated variables, such as specific humidity at 850kPa.

The model used to generate the local climate change scenarios was the Statistical Downscaling Model (SDSM), developed by Wilby, Dawson, and Barrow (Lines *et al.*, 2003). This model is available for public use and can be downloaded from the SDSM UK website. A brief description of the model follows; a full description can be found in the SDSM 'Users Manual', which is available at the website (SDSM UK website).

This model can be best described as a hybrid of a stochastic weather generator and regression-based methods. Predictors, such as mean temperature, were chosen and the statistical relationship between the predictors and a related predictand, such as minimum or maximum temperature, was calculated. This resulted in a set of regression equations, which were used to develop scenarios for the predictand(s) in the future, based on the values of the predictors produced by the GCM's. In order to obtain the set of equations, there must be a set of predictor variables that are recalculated on the same grid as the GCM, from the observational data set. This data set was obtained by interpolating the National Center for Environmental Prediction (NCEP) Re-analysis data set with the CGCM1 grid (NCEP website). The variables from the data set gridded to the GCM grid were then screened by the SDSM to determine the explained variance between the predictand and predictors when compared statistically. This allowed the user to choose the predictors with the best-explained variance with respect to the predictand, as well as some reasonable physical relationship and a low degree of standard error. For example, the predictor with the best fit to the above criteria in predicting the minimum temperature was the mean temperature.

After the predictors and predictand were chosen, the model was calibrated. A parameter file was created based on the predictor-predictand relationship. From the parameter file, a set of synthesized data for a known period was created. This created data set, covering 1961-1990 for this study, was compared to recorded observational data (see description in Part I, Section 2.1) to measure the effectiveness of the model. In this case, calibrating on the first half of the observational data set and testing on the second half validated the model. After the validity of the model had been determined, the SDSM was run using the GCM outputs for both current and future periods.

1.2 Overview of Results

Results were computed at the 95% confidence level. The average maximum and minimum temperatures were projected for each site for all three future time periods. In addition, several other temperature variables were examined. A summary of these variables is given in the table below.

Table II.1 Temperature variables defined with respect to the SDSM climate change scenarios.

Variable	Definition
Frost-free days	Days with minimum temperatures above 0°C
Hot days	Days with maximum temperatures above 25°C
Extremely Hot days	Days with maximum temperatures above 30°C

The precipitation results are given for several variables. The mean monthly precipitation amounts (given in mm), extreme precipitation (defined, as for the historical record, as the 95th percentile level, given in mm), and percentage (%) of wet days are all given for both sites. The average number of consecutive days with no precipitation and the average number of consecutive days with precipitation, defined as mean dry spell and mean wet spell, and the maximum dry spell and maximum wet spell were calculated as well. The results are discussed in detail in the next sections.

It should be noted that the downscaled scenarios in this study were generated using only one GCM model running one emission scenario. Downscaled scenarios using other GCM models and different experiments would likely produce slightly different, but equally plausible, results.

Section Two: Future Temperature Scenarios – Results & Discussion

Further graphical representations and details of analysis for this section are provided in Appendix D.

2.1 Kentville

The plausible future temperature scenarios for Kentville indicated an increase in the mean minimum and maximum temperatures. The three future periods and the observed values from the 1961 to 1990 period for the mean maximum and minimum temperatures are represented graphically in Figure II-1 and II-2.

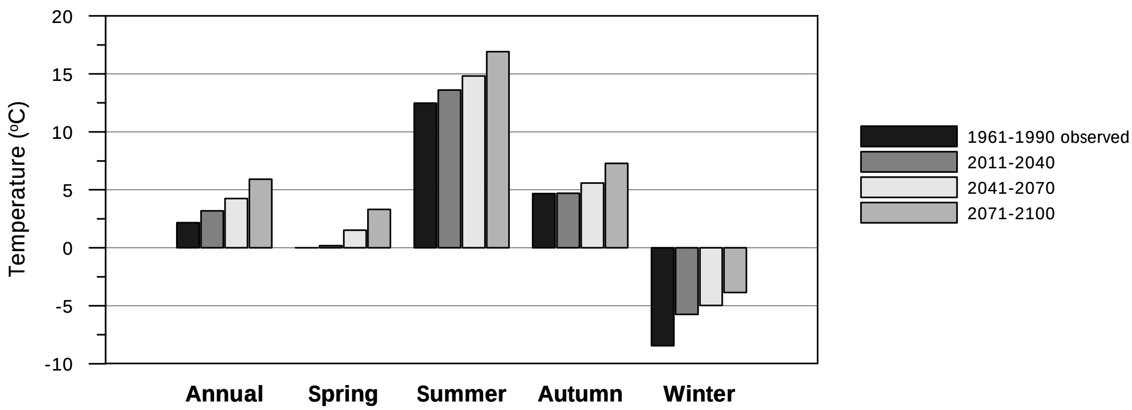

Figure II-1 Comparison of observed and projected mean minimum temperatures for Kentville: 1961 to 1990 observed, 2011 to 2040 projected, 2041 to 2070 projected, and 2071 to 2100 projected.

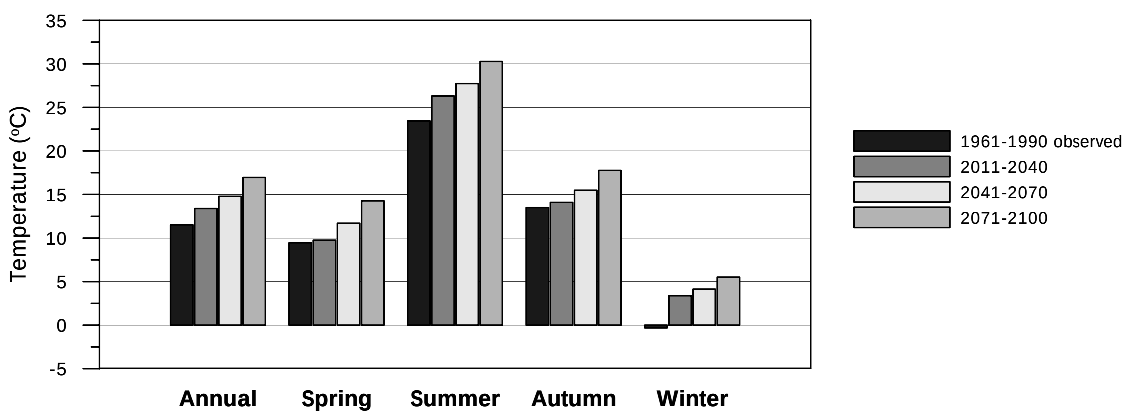

Figure II-2 Comparison of observed and projected mean maximum temperatures for Kentville: 1961 to 1990 observed, 2011 to 2040 projected, 2041 to 2070 projected, and 2071 to 2100 projected.

2011 to 2040

The plausible future climate scenario projection for 2011 to 2040 in Kentville indicated a rise in the annual mean minimum temperature, over the observed period of 1961-1990, of just over one degree Celsius. The annual mean maximum temperature was also projected to increase, by 1.9°C. The seasonal mean minimum temperatures also increased, with the summer and winter season showing the biggest increases, of 1.1°C and 2.7°C, respectively. The biggest increases in the mean maximum temperature also occurred in the summer and winter seasons, at 2.9°C and 3.7°C, respectively, though the spring and autumn temperatures were also projected to increase by smaller margins. These increases are portrayed graphically in Figures II-1 and II-2.

The projected changes in the percentages of frost-free days, hot days and extremely hot days in Kentville from the base period of 1961-1990 to 2011-2040 are given in Table II-2. Though the mean minimum and maximum temperatures were projected to increase, a slight decrease in the percentage of frost-free days was projected annually, and during the spring and autumn months. The spring and autumn temperature increases were small in magnitude, with the mean minimum temperature in the spring only slightly above freezing. The winter months showed an increase in the percentage of frost-free days of 4%. The percentage of hot days was projected to increase annually, with the biggest increase in the summer months, of 26%, and small increases in the spring and autumn months. The extremely hot days were also projected to increase annually, with an increase in the summer months of 20%.

Table II-2 Projected change in percentage of frost-free days, hot days, and extremely hot days from 1961-1990 observed period to 2011-2040 in Kentville.

	Frost-free Days (minimum temperature above 0°C)	Hot Days (maximum temperature above 25°C)	Extremely Hot Days (maximum temperature above 30°C)
Annual	-1%	9%	6%
Spring	-3%	3%	1%
Summer	--	26%	20%
Autumn	-4%	6%	1%
Winter	4%	--	--

Graphical representations of the information in this table, and corresponding values, can be found in Appendix D – Graphs DK.01 through DK.03, Table D.01.

2041 to 2070

The second projected period showed increases in the annual mean minimum and maximum temperatures which were larger than the increases in the previous period. The annual mean minimum temperature increase was projected at over two degrees and the annual mean maximum temperature increase at over three degrees compared to 1961-1990. Seasonally, the increases were larger in the summer and winter months, with the mean maximum temperatures in each of those two seasons projected to increase by over four degrees. The graphical representations of these changes are shown in Figures II-1 and II-2.

The percentage of frost-free days was projected to increase annually over this time period, as shown in Table II-3. The largest increases in the percentage of frost-free days occurred in the spring and winter months, with increases of 7% and 8%. The percentage of hot days and extremely hot days increased annually over the observed base period of 1961-1990. The increases were largest in the summer months, as would be expected, with the hot days increasing by 36% and the extremely hot days by 31%. There was a 10% increase in the percentage of hot days during the autumn months.

Table II-3 Projected change in percentage of frost-free days, hot days, and extremely hot days from 1961-1990 observed period to 2041-2070 in Kentville.

	Frost-free Days (minimum temperature above 0°C)	Hot Days (maximum temperature above 25°C)	Extremely Hot Days (maximum temperature above 30°C)
Annual	4%	13%	9%
Spring	7%	6%	2%
Summer	--	36%	31%
Autumn	1%	10%	3%
Winter	8%	--	--

Graphical representations of the information in this table, and corresponding values, can be found in Appendix D – Graphs DK.01 through DK.03, Table D.01.

2071 to 2100

For Kentville, the final projected period showed large increases in the annual mean minimum temperature and annual mean maximum temperature. The annual mean minimum temperature increase was over 3.5°C, while the annual mean maximum temperature increased by almost 5.5°C. These increases can be seen in Figures II-1 and II-2. The seasons showed larger increases for this period. The spring temperatures increased by over three degrees in the minimum temperature and over 4.5° for the maximum temperature. The seasonal mean minimum temperatures all increased, with magnitudes ranging between 2.6° in the autumn and almost 4.6° in the summer. The seasonal mean maximum temperatures also increased, all by over four degrees. The summer maximum temperature increased as during the previous periods. The increase was larger, with a projected increase of close to 7°.

The increases in the percentages of frost-free days, hot days and extremely hot days are given in Table II-4. The largest increases in the percentage of frost-free days occurred during this final projected period. Annually, the increase was 10%, with the increases in the spring and winter both over 15%. The percentage of hot days increased annually by 20%. The increases in the spring and autumn months both exceeded 10% for this period but the summer months displayed the largest increase, almost 50%. The number of extremely hot days increased by 15% annually, with the vast majority of the days expected to occur during the summer months. The increase for the summer exceeded 50%.

Table II-4 Projected change in percentage of frost-free days, hot days, and extremely hot days from the 1961-1990 observed period to 2071-2100 for Kentville.

	Frost-free Days (minimum temperature above 0°C)	Hot Days (maximum temperature above 25°C)	Extremely Hot Days (maximum temperature above 30°C)
Annual	10%	20%	15%
Spring	18%	12%	5%
Summer	--	49%	51%
Autumn	6%	17%	6%
Winter	14%	--	--

Graphical representations of the information in this table, and corresponding values, can be found in Appendix D – Graphs DK.01 through DK.03, Table D.01.

2.2 Greenwood

An overall picture of the changes in mean minimum and mean maximum temperatures for Greenwood for the plausible future climate scenarios can be seen in Figures II-3 and II-4. A more detailed discussion of the results follows.

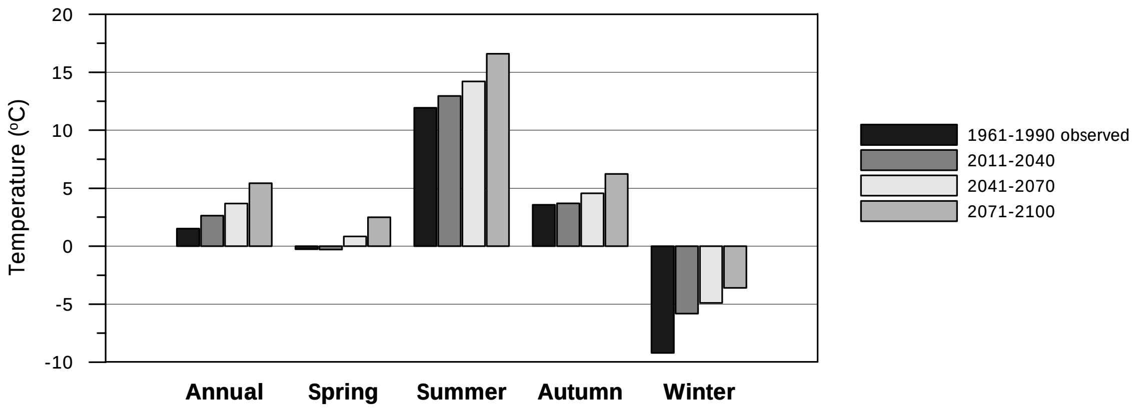

Figure II-3 Comparison of observed and projected mean minimum temperatures for Greenwood: 1961 to 1990 observed, 2011 to 2040 projected, 2041 to 2070 projected, and 2071 to 2100 projected.

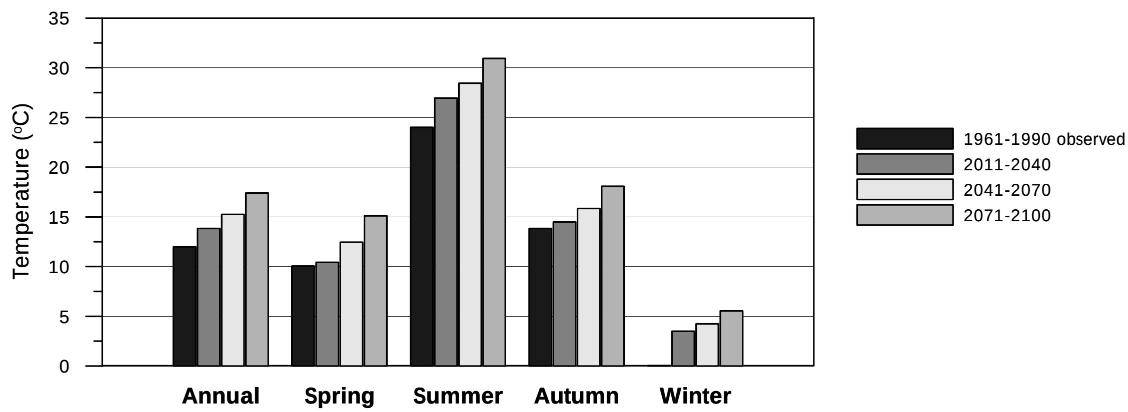

Figure II-4 Comparison of observed and projected mean maximum temperatures for Greenwood: 1961 to 1990 observed, 2011 to 2040 projected, 2041 to 2070 projected, and 2071 to 2100 projected.

2011 to 2041

The annual mean minimum temperature in Greenwood was projected to increase by just over one degree for the period from 2011 to 2040 compared to the base period of 1961 to 1990. The increase in the annual mean maximum temperature was larger, at almost 1.9°C. Seasonally, the spring mean minimum temperature remained approximately the same as the base period while the autumn temperature increased slightly. The summer mean minimum temperature increased by 1°C. The winter mean minimum temperature increased by the largest amount, over three degrees. The mean maximum temperatures increased slightly in the spring and autumn months. The summer and winter maximum temperatures showed larger increases, at just under 3°C in the summer and over 3°C for the winter.

For Greenwood during this period, the annual percentage of frost-free days was projected to remain consistent with the observed base period of 1961-1990, as shown in Table II-5. There was an increase in the percentage during the winter months but the other seasons showed slight decreases in the percentages. The annual percentage of hot days was expected to rise, by 9% over the year. The majority of this increase was expected in the summer months, where the increase was 25%. The percentage of extremely hot days showed a smaller increase than the hot days, at 6%. Again, the vast majority of this increase was projected for the summer, as would be expected.

Table II-5 Projected change in the percentage of frost-free days, hot days, and extremely hot days from the 1961-1990 observed period to 2011-2040 in Greenwood.

	Frost-free Days (minimum temperature above 0ºC)	Hot Days (maximum temperature above 25ºC)	Extremely Hot Days (maximum temperature above 30ºC)
Annual	0%	9%	6%
Spring	-5%	4%	1%
Summer	--	25%	23%
Autumn	-3%	6%	1%
Winter	7%	--	--

Graphical representations of the information in this table, and corresponding values, can be found in Appendix D – Graphs DG.01 through DG.03, Table D.02.

2041 to 2070

The annual mean minimum temperature in Greenwood was projected to rise by over two degrees for this future period compared to the base period 1961-1990. The annual mean maximum temperature was also projected to rise, by over three degrees. The seasonal temperature changes varied in their magnitude but all the minimum and maximum temperatures showed an increase. The smallest increase was projected for the autumn mean minimum temperature, at just under one degree, with the largest increase in the summer mean maximum temperature, at over four degrees. These changes are shown graphically in Figures II-3 and II-4.

Table II-6 Projected change in the percentage of frost-free days, hot days and extremely hot days from the 1961-1990 period to 2041-2070 in Greenwood.

	Frost-free Days (minimum temperature above 0ºC)	Hot Days (maximum temperature above 25ºC)	Extremely Hot Days (maximum temperature above 30ºC)
Annual	4%	13%	10%
Spring	3%	7%	3%
Summer	--	34%	35%
Autumn	1%	10%	3%
Winter	11%	--	--

Graphical representations of the information in this table, and corresponding values, can be found in Appendix D – Graphs DG.01 through DG.03, Table D.02.

The changes in percentages of frost-free days, hot days and extremely hot days for this period are given in Table II-6. The annual percentage of frost-free days showed a slight increase of 4%. The spring and autumn percentages increased by a marginal amount but the winter increase was larger, at 11%. The percentage of hot days during the year increased over the base period by 13%, with the majority of the increase occurring during the summer months. The extremely hot days increased by 10% over the entire year. The increase occurred in the summer months, with very little increase in the spring and autumn.

2071 to 2100

As shown in Figures II-3 and II-4, the final period at the end of the century had the highest mean minimum and maximum temperatures. The annual increases were almost four degrees in the mean minimum temperature and over five degrees in the mean maximum temperature. Seasonally, the increases above the observed base period of 1961-1990 were large, with the increase in the summer maximum temperature expected to reach almost 7°C. The smallest increases were expected in the autumn, for both the mean minimum and maximum temperatures. The winter minimum temperature increased by 5.6°C, the largest increase in the mean minimum temperatures.

The projected increase in the annual percentage of frost-free days was 9%, with a considerable increase in both the spring and autumn compared to the earlier periods. The increases are shown in Table II-7. The largest increase fell in the winter, double the annual increase, at 18%. The percentage of hot days increased over the year by almost 20%, with a 46% increase in the summer months. The spring and autumn months showed considerable increases in the percentage of hot days as well, at 14% and 17%, respectively. The extremely hot days increased by almost the same percentage as the hot days, 17% annually. The increases in the spring and summer were larger than previous periods but the vast majority of the increase occurred in the summer.

Table II-7 Projected change in the percentage of frost-free days, hot days, and extremely hot days from the 1961-1990 period to 2071-2100 in Greenwood.

	Frost-free Days (minimum temperature above 0°C)	Hot Days (maximum temperature above 25°C)	Extremely Hot Days (maximum temperature above 30°C)
Annual	9%	19%	17%
Spring	12%	14%	6%
Summer	--	46%	53%
Autumn	7%	17%	6%
Winter	18%	--	--

Graphical representations of the information in this table, and corresponding values, can be found in Appendix D — Graphs DG.01 through DG.03, Table D.02.

2.3 Comparison of Projected Temperature Changes for Kentville and Greenwood

A comparison of the base periods in Kentville and Greenwood showed a higher mean minimum temperature in Kentville and a higher mean maximum temperature in Greenwood. The differences between the Kentville and Greenwood temperatures were not large. The annual mean minimum temperature in Kentville was about 0.5 degrees higher than Greenwood, while the mean maximum temperature in Kentville was about 0.5 degrees lower than Greenwood. The annual and seasonal mean minimum and maximum temperatures were very close for the entire century, the differences were one degree or less.

The difference in the annual percentage of frost-free days for the two sites was less than 2% throughout the century. The seasonal differences were a little larger in the spring, autumn and winter months, reaching 5% for some of the periods. The percentage of hot days differed by less than 2% as well, across the periods and most of the seasons. The summer difference decreased from the base period to the end of the century. The percentages of extremely hot days were very similar across the century as well, with the biggest difference between the two sites appearing in the summer months where Greenwood showed a higher percentage by about 5% over the projected periods.

Section Three: Future Precipitation Scenarios - Results & Discussion

Further graphical representations and details of analysis for this section are provided in Appendix E.

3.1 Kentville

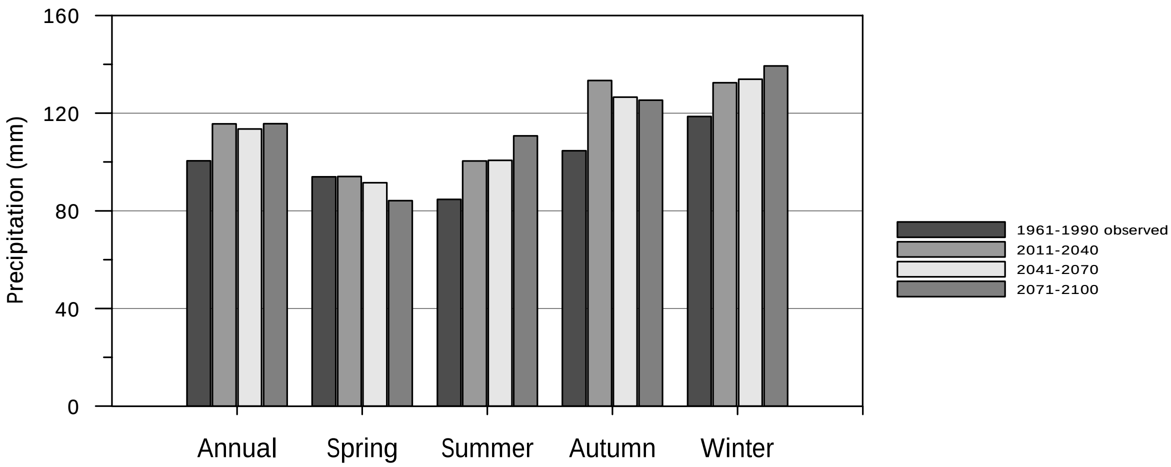

Figure II-5 Mean monthly precipitation amounts in Kentville projected from SDSM climate change scenarios compared to observed amounts.

2011 to 2040

The overall plausible future precipitation scenario for Kentville for 2011 to 2040 showed an increase in the monthly mean precipitation amounts averaged over the entire year. The changes in the monthly mean precipitation amounts are illustrated graphically in Figure II-5. The increase was over 15mm per month over the year. The spring months remained consistent with the observed period. The summer and winter months both increased, by over 15mm per month in the summer and almost 14mm in the winter. The autumn months showed the largest increase, at close to 30mm. The increases in the other precipitation variables over the observed period are given in Table II-8. The annual extreme precipitation threshold increased over the observed period, as did the summer and autumn thresholds. The autumn threshold increased by a large margin, of almost 6mm. The spring and winter thresholds decreased over the observed period. The percentage of wet days decreased annually. The seasonal and annual changes were all less than 10%.

The annual mean number of consecutive days without precipitation, or mean dry spell, decreased over the observed period. The seasonal spells also decreased. The differences over the observed period were small, with no change over half a day. The winter spell showed a slight increase. The annual maximum number of consecutive days with no precipitation, or maximum dry spell, showed no change over the observed period. The seasonal changes were small, with the largest difference an increase of 0.7 days in the winter. The annual mean number of consecutive days with precipitation, or mean wet spell, decreased slightly over the observed period. The seasonal mean wet spells decreased, all by half a day or less. The maximum number of consecutive days with precipitation, or maximum wet spell, decreased slightly over the year. The seasonal maximum wet spells decreased during the spring (-0.4 days), summer

(-0.2 days) and winter (-0.9 days). The autumn months increased the maximum number of consecutive wet days by one day.

Table II-8 Projected changes in precipitation variables for Kentville from the 1961-1990 observed period to the period 2011-2040.

	Extreme Precipitation (mm)	Percentage of Wet Days	Mean Dry Spell (days)	Maximum Dry Spell (days)	Mean Wet Spell (days)	Maximum Wet Spell (days)
Annual	1.0	-3%	-0.2	0.0	-0.3	-0.1
Spring	-2.3	-4%	-0.3	-0.4	-0.5	-0.4
Summer	1.5	0%	-0.1	0.0	-0.1	-0.2
Autumn	5.9	1%	-0.4	-0.2	-0.1	1.0
Winter	-1.2	-7%	0.2	0.7	-0.5	-0.9

Graphical representations of the information in this table, and corresponding values, can be found in Appendix E – Graphs EK.01 through EK.06, Tables EK.01 and EK.02.

2041 to 2070

The mean monthly precipitation increased annually over the observed base period for the projected period from 2041-2070. The summer, autumn and winter months all showed an increase in the mean monthly precipitation amounts. The spring months showed a decrease from the observed period. These changes in mean monthly precipitation are shown in Figure II-5. The annual extreme precipitation threshold increased by 0.5mm over the observed period. The seasonal thresholds varied in their changes, as shown in Table II-9. The summer and autumn thresholds increased, by 1.8mm and 4.3mm, respectively. The spring and winter thresholds displayed an opposite trend, decreasing by 2.6mm and 1.3mm, respectively. The percentage of wet days decreased annually over the observed period by the same amount as the 2011-2040 period. There was a decrease of 10% in the winter percentage, with the other seasons displaying smaller changes.

Table II-9 Projected changes in precipitation variables for Kentville from the 1961-1990 observed period to the period 2041-2070.

	Extreme Precipitation (mm)	Percentage of Wet Days	Mean Dry Spell (days)	Maximum Dry Spell (days)	Mean Wet Spell (days)	Maximum Wet Spell (days)
Annual	0.5	-3%	-0.1	-0.4	-0.3	-0.2
Spring	-2.6	-4%	-0.2	-0.5	-0.5	-0.7
Summer	1.8	1%	-0.2	-1.4	-0.1	-0.3
Autumn	4.3	2%	-0.3	-0.8	0.0	1.7
Winter	-1.3	-10%	0.3	0.9	-0.6	-1.4

Graphical representations of the information in this table, and corresponding values, can be found in Appendix E – Graphs EK.01 through EK.06, Tables EK.01 and EK.02.

The changes in the mean dry spells were small, all less than a half a day. The changes were all decreases over the observed period with the exception of the winter months, which showed a slight increase. The maximum dry spells decreased annually by less than half a day. The seasonal maximum dry spells changed by larger margins than the annual spell. The summer maximum dry spell showed the largest decrease, almost 1.5 days. The winter months showed the only increase, at just under one day. The mean wet spell length decreased annually, as did the maximum wet spell, both by small amounts of less than half a day. The seasonal spells showed more variation. The spring wet spells decreased in length, both changes amounting to less than one day. The summer wet spells displayed the smallest changes, on the same order as the annual changes. The autumn mean wet spell showed no change, the maximum wet spell increased by over 1.5 days. The winter wet spells decreased in length, with the maximum wet spell decreasing by almost a day and a half.

2071 to 2100

The mean monthly precipitation projections for the period from 2071 to 2100 showed an increased amount of precipitation over the base period of 1961-1990, as illustrated in Figure II-5. The increase was similar to the other two projected periods, at slightly over 15mm. The seasonal changes were identical in direction to the previous periods, with increasing amounts in the summer, autumn and winter, and decreasing amounts in the spring. The magnitude of the differences between the base period and this final period were similar to the previous periods, with a larger decrease of almost 10mm in the spring and an increase of over 25mm in the winter. The changes in other precipitation variables are given in Table II-10. The extreme precipitation threshold increased annually, with increases during the summer and autumn months of over 4mm. The spring threshold decreased by over 4mm, with a small increase over the winter. The percentage of wet days decreased slightly over the entire year, with the largest decrease in the winter months. A slight increase was shown for the summer and autumn months.

Table II-10 Projected changes in precipitation variables for Kentville from the 1961-1990 observed period to the period 2071-2100.

	Extreme Precipitation (mm)	Percentage of Wet Days	Mean Dry Spell (days)	Maximum Dry Spell (days)	Mean Wet Spell (days)	Maximum Wet Spell (days)
Annual	1.2	-4%	-0.1	0.7	-0.3	-0.1
Spring	-4.3	-6%	-0.1	0.6	-0.5	-0.9
Summer	4.7	2%	-0.2	0.4	0.0	0.8
Autumn	4.1	4%	-0.5	-0.2	0.0	2.1
Winter	0.4	-14%	0.5	2.0	-0.7	-2.5

Graphical representations of the information in this table, and corresponding values, can be found in Appendix E – Graphs EK.01 through EK.06, Tables EK.01 and EK.02.

The mean and maximum dry spells showed little change between this period and the base period. The mean dry spells decreased annually, and during the spring, summer and autumn months. The decreases were small, less than half a day. The winter months showed an increase in the length of the mean dry spell, by half a day. The maximum dry spell increased by less than a day over the year, as well as during the spring and summer months. The autumn maximum dry spell showed a small decrease of 0.2 days. The winter maximum dry spell increased by a larger amount, two days. The mean wet spell decreased slightly over the year, and during the spring and winter months. The changes were all less than one day. The summer and autumn months showed no change in the mean wet spell length from the base period. The maximum wet spell also decreased annually, by a small amount. The spring maximum wet spell decreased by less than one day while the summer maximum wet spell increased by the same. The changes in the autumn and winter were larger, the autumn maximum wet spell increased by over two days while the winter spell decreased by 2.5 days.

3.2 Greenwood

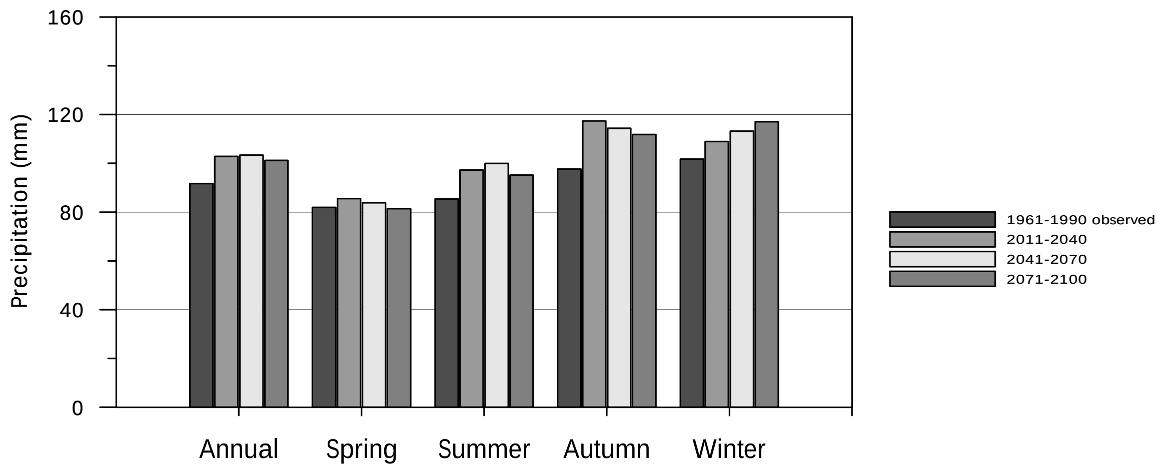

Figure II-6 Mean monthly precipitation amounts in Greenwood projected from SDSM climate change scenarios, compared to observed.

2011 to 2040

For Greenwood, the mean monthly precipitation amounts projected for 2011 to 2040, showed the same variability by season as was evident in the Kentville scenarios. Annually, the mean monthly precipitation amounts increased for this period, with an increase of 11mm per month over the base period from 1961-1990. The distribution of this increase varied by season, although all four seasons showed an increase. The biggest increase occurred for the autumn months, at almost 20mm. The increases in the mean monthly precipitation are illustrated in Figure II-6. The changes from the base period for the extreme precipitation thresholds and the other precipitation variables are given in Table II-11. The extreme precipitation thresholds increased for this period, with the exception of the winter months where the threshold decreased by over 2mm. The biggest increase was projected for the autumn months. Though the amounts of precipitation are expected to increase according to these numbers, the percentage of wet days was expected to decrease over the entire year by 2%. The spring and winter months both showed decreases, of 6% for the spring and 5% for the winter.

Table II-11 Projected changes in precipitation variables for Greenwood from the 1961-1990 observed period to the period 2011-2040.

	Extreme Precipitation (mm)	Percentage of Wet Days	Mean Dry Spell (days)	Maximum Dry Spell (days)	Mean Wet Spell (days)	Maximum Wet Spell (days)
Annual	0.9	-2%	-0.3	-1.5	-0.4	-1.3
Spring	0.2	-6%	-0.2	-0.2	-0.5	-2.5
Summer	1.4	0%	-0.4	-2.1	-0.2	-0.4
Autumn	4.2	2%	-0.5	-2.0	-0.1	0.7
Winter	-2.3	-5%	0.0	-1.8	-0.7	-3.0

Graphical representations of the information in this table, and corresponding values, can be found in Appendix E – Graphs EG.01 through EG.06, Tables EG.01 and EG.02.

The mean dry spells decreased across all the time periods. The annual decrease was 0.3 days and the biggest decrease in any season was the autumn decrease of half a day. The maximum dry spells also decreased annually and across all the seasons. The annual decrease was 1.5 days. The spring decrease was small but the other three seasons were all more than one day. The mean wet spells also decreased during this period, all by less than one day. The annual maximum wet spell decreased across this period, by a little more than a day. The biggest changes occurred in the spring, where the maximum wet spell decreased by 2.5 days, and in the winter, with a decrease of three days.

2041 to 2070

The mean monthly precipitation in Greenwood increased for the projected period 2041 to 2070, over the base period of 1961-1990. The changes were not large; an annual mean increase of just under 12mm was projected. The spring months increased by only 2mm; the other seasons increased by larger amounts, all above 10mm. These changes are portrayed graphically in Figure II-6. The changes in extreme precipitation thresholds and the other precipitation variables are shown in Table II-12. The annual extreme precipitation threshold increased very little over the base period; the summer and autumn thresholds showed greater increases, with 2.5mm in the summer and 3.8mm in the autumn. The winter threshold decreased by 1.6mm. The percentage of wet days decreased by 2% over the year, with decreasing percentages in the spring and winter months, both by 6%. The summer and autumn showed small increases in the percentage of wet days.

Table II-12 Projected changes in precipitation variables for Greenwood from the 1961-1990 observed period to the period 2041-2070.

	Extreme Precipitation (mm)	Percentage of Wet Days	Mean Dry Spell (days)	Maximum Dry Spell (days)	Mean Wet Spell (days)	Maximum Wet Spell (days)
Annual	1.1	-2%	-0.2	-1.5	-0.4	-1.4
Spring	-0.1	-6%	-0.2	-0.7	-0.5	-2.4
Summer	2.5	1%	-0.4	-1.7	-0.2	-0.3
Autumn	3.8	2%	-0.4	-2.1	-0.1	0.5
Winter	-1.6	-6%	0.0	-1.4	-0.7	-3.6

Graphical representations of the information in this table, and corresponding values, can be found in Appendix E – Graphs EG.01 through EG.06, Tables EG.01 and EG.02.

The changes in the length of the mean dry spell for this period were small. The biggest change was a decrease of 0.4 days in both the summer and autumn months; the winter months did not change. The seasonal maximum dry spells changed by over a day, with the exception of the spring spell, decreasing in the annual and all four seasons. The mean wet spells decreased for all time periods, with the biggest decrease in the winter months at 0.7 days. The maximum wet spells also decreased, with the exception of the autumn months. The decreases were larger for the annual maximum wet spell, and the spring and winter months. All of these decreases were over one day. The autumn increase was only half a day.

2071 to 2100

For the final projected period, from 2071 to 2100, the mean monthly precipitation increased over the base period, by a smaller amount than the previous two projected periods. The spring mean monthly precipitation decreased slightly (only 0.5mm), while the other three seasons increased. The mean monthly precipitation projections are shown in Figure

II-6. The changes in the other precipitation variables over the base period are given in Table II-13. The extreme precipitation threshold increased annually, by less than 1mm. The spring and winter projections showed small decreases while the summer and autumn showed large increases; the summer exceeded 1mm while the autumn exceeded 3mm. The percentage of wet days decreased annually, as well as over the spring and winter months. The summer and autumn months showed an increase in the percentage of wet days. The winter had the biggest change, with a decrease of 8%.

Table II-13 Projected changes in precipitation variables for Greenwood from the 1961-1990 observed period to the period 2071-2100.

	Extreme Precipitation (mm)	Percentage of Wet Days	Mean Dry Spell (days)	Maximum Dry Spell (days)	Mean Wet Spell (days)	Maximum Wet Spell (days)
Annual	0.9	-2%	-0.3	-1.5	-0.4	-1.5
Spring	-0.3	-6%	-0.1	-0.7	-0.6	-2.7
Summer	1.1	2%	-0.4	-1.7	-0.1	-0.1
Autumn	3.2	3%	-0.5	-2.6	-0.1	0.6
Winter	-0.4	-8%	0.1	-1.3	-0.8	-3.9

Graphical representations of the information in this table, and corresponding values, can be found in Appendix E – Graphs EG.01 through EG.06, Tables EG.01 and EG.02.

The mean dry spells for this period showed little variation over the base period. The annual mean dry spell decreased, as did the spring, summer and autumn mean dry spells. The winter spell showed a slight increase. The maximum dry spell decreased annually and for all the seasons. The decreases ranged from a low of less than one day for the spring to more than 2.5 days for the autumn. The mean wet spells also decreased across all the seasons. The decreases were small, less than half a day for all except the spring (0.6 days) and the winter (0.8 days). The maximum wet spells all decreased, except for the autumn months. The annual maximum wet spell decreased by 1.5 days, while the spring decreased by over 2.5 days and the winter decreased by just under four days.

3.3 Comparison of Plausible Precipitation Scenarios in Kentville and Greenwood

The mean monthly precipitation amounts in Kentville and Greenwood were very similar, with more precipitation in Kentville during the winter and spring months. Kentville continued to show more precipitation during the winter months, with the difference between the sites in the spring narrowing throughout the century. The differences in the extreme precipitation thresholds remained relatively consistent with the differences that were observed in the base period. The differences in the percentages of wet days between the two sites were less than 3% for all the time periods and seasons with the exception of the winter months. Greenwood showed a higher percentage of wet days during the winter months; the difference increased over the century.

The mean dry spell lengths varied between the two sites by less than a day throughout the seasons and the century. The length of the mean wet spells also varied by less than a day between the two sites. The maximum dry spells showed greater differences. Greenwood showed longer maximum dry spells in the summer and autumn versus Kentville, by one day or greater. The majority of the projected seasons showed differences of less than one day. There were a few exceptions to this: the winter projections for all three future periods showed Kentville with maximum dry spells longer than those in Greenwood of more than two days. The maximum wet spells were longer in Greenwood during the base period; by over 1.5 days over the entire year and in the spring. The Greenwood maximum wet spell was longer in the winter by over 4.5 days. The differences over the future periods were smaller; less than one day annually, and during the spring and autumn. Greenwood showed longer maximum wet spells but the difference was smaller.

Section Four: Summary & Conclusions for Plausible Future Climate Scenario

4.1 Summary of Plausible Future Temperature Scenario

Results and Discussion presented in Section Two

The plausible future temperature scenarios in Kentville and Greenwood projected increasing temperatures over this century. Both the mean minimum temperature and mean maximum temperature increased over the next 100 years. The mean minimum temperature during the winter was expected to reach –4°C for both locations. The mean maximum temperature in the summer was projected to exceed 30°C for both locations. The percentage of frost-free days (minimum temperature over 0°C) in Kentville over the winter was projected to reach 22% by the end of the century, while in Greenwood the percentage was expected to reach 25%. The percentage of hot days (maximum temperature over 25°C) in the summer was expected to reach 85% in Kentville by the end of the century, with Greenwood reaching 87% of summer days over 25°C. The extremely hot days (maximum temperature over 30°C) also increased over the century; Kentville increased to 54% and Greenwood increased to 59% of summer days.

4.2 Summary of Plausible Future Precipitation Scenario

Results and Discussion presented in Section Three

The precipitation projections for the two locations were very similar. Kentville showed increasing mean monthly precipitation during the summer, autumn and winter; decreasing in the spring. The extreme precipitation thresholds (95^{th} percentile amount) decreased in the spring and increased in the summer and autumn. The percentage of wet days in Kentville changed by less than 10% over the century, with the exception of the winter months, where the decrease took the number of wet days from 52% over the 1961-90 period to 38% over the 2071-2100.

The projections for Greenwood showed the same trend for the mean monthly precipitation; increasing amounts in the summer, autumn and winter, while the spring amount remained within 1mm of the base period at the end of the century. The extreme precipitation thresholds remained very close to the base period to the end of the projected periods, with the exception of the autumn threshold, which increased by over 3mm. The percentage of wet days in Greenwood remained very similar to the base period over the projected periods.

The mean dry spells changed by only hours for both sites over the century. The mean wet spells also changed by a matter of hours over the projected periods. The maximum dry and wet spells displayed greater changes. The maximum dry spell in Kentville showed an increase of two days for the winter months, the other seasons increased by less than one day (with a small decrease in the autumn). In Greenwood, the maximum dry spells decreased by less than two days with the exception of the autumn months where the spell decreased by more than 2.5 days. The maximum wet spells changed in length by less than one day during the spring (decreased) and summer (increased) in Kentville. The autumn maximum wet spells increased by two days while the winter spells decreased by 2.5 days. For Greenwood, the changes in maximum wet spell were within one day during the summer (decreased) and autumn (increased). The spring maximum wet spell decreased by over 2.5 days while the winter maximum wet spell decreased by four days.

4.3 Conclusions

The plausible climate change scenarios for Kentville and Greenwood showed a varying picture by season of the future climate in the area. The spring months were expected to be warmer and drier; with more days above freezing, less precipitation and fewer wet days. The warmer temperatures could mean an earlier spring thaw. The summer months were warmer and wetter; with higher temperatures and increased mean monthly precipitation. The temperatures during the summer showed the majority of days reaching 25°C, and over half reaching 30°C. The autumn months were also warmer and wetter; with increased temperatures, increased mean monthly precipitation and increased extreme precipitation thresholds. The number of days above freezing increased, as well as the number of days reaching 25°C. The increase in the extreme precipitation threshold could indicate an increase in the number of extreme events, as autumn is hurricane season. The winter months were warmer and wetter; with increasing temperatures, increasing mean monthly precipitation but a decreasing number of wet days. The extreme precipitation thresholds remained similar to the current, indicating an increase for each wet day, rather than larger extreme events. The number of days above freezing increased to over 20% for the winter.

PART III

OVERALL SUMMARY, IMPLICATIONS AND REFERENCES

Section One: Overall Summary and Implications

This study has attempted to characterize the past, current and future climate of the Annapolis Valley, by providing details of the historical and projected changes in the most common climate variables. While there is a variety of parameters that can be studied, the focus of this work has been on temperature (maximum and minimum) and precipitation (amount). The results provided historical trends at the sites chosen, Kentville and Greenwood, as well as relevant projections of future climate variables, thus enhancing knowledge about the nature of the Annapolis Valley climate and how it could change in the future.

1.1 Temperature

Historically, both sites have shown warming trends in the minimum temperature (Figures III-1 and III-2); with the warming almost a tenth of a degree C per decade for Kentville and two-tenths of a degree C per decade for Greenwood (Tables III-1 and III-2). While that may seem small, it implies a century warming trend in the 1-2 degree range. This is compatible with results attained by other researchers for other sites across Canada (Zhang *et al*., 2000) and globally.

Table III–1 Summary of historical and projected values and trends for the average annual minimum temperature (Tmin) in Greenwood. Mean Tmin for base period 1961-1990 was 1.5°C (274.7K).

Decadal Trends		Projected Change from 1961-1990		
Period	Trend (°C/decade)	Period	Change (expressed as °C)	Change (expressed as %)
1943 to 1999	0.2			
1975 to 2025	0.2	2011 to 2040	1.1	0.4
2025 to 2055	0.4	2041 to 2070	2.2	0.8
2055 to 2085	0.6	2071 to 2100	3.9	1.4

Table III-2 Summary of historical and projected values and trends for average annual minimum temperature (Tmin) in Kentville. Mean Tmin for base period 1961-1990 was 2.2°C (275.4K).

Decadal Trends		Projected Change from 1961-1990		
Period	Trend (°C/decade)	Period	Change (expressed as °C)	Change (expressed as %)
1914 to 1995	0.1			
1975 to 2025	0.2	2011 to 2040	1.0	0.4
2025 to 2055	0.4	2041 to 2070	2.1	0.8
2055 to 2085	0.6	2071 to 2100	3.7	1.4

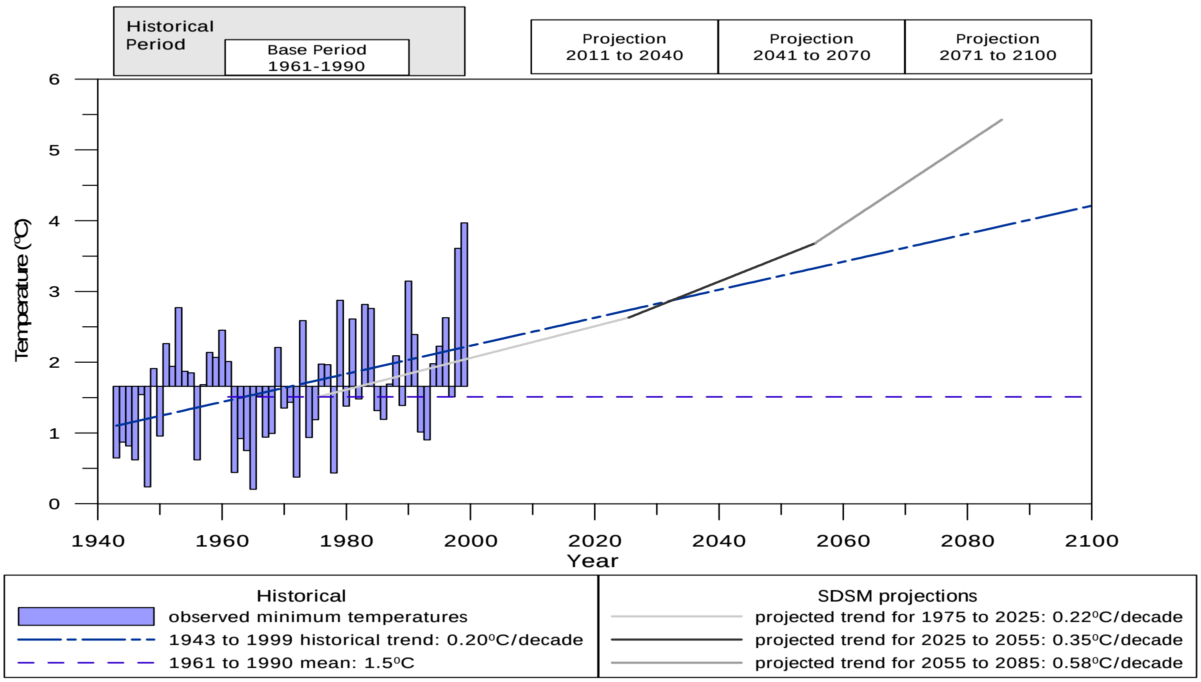

Figure III-1 Summary of historical and projected mean minimum temperature trends to 2100 in Greenwood.

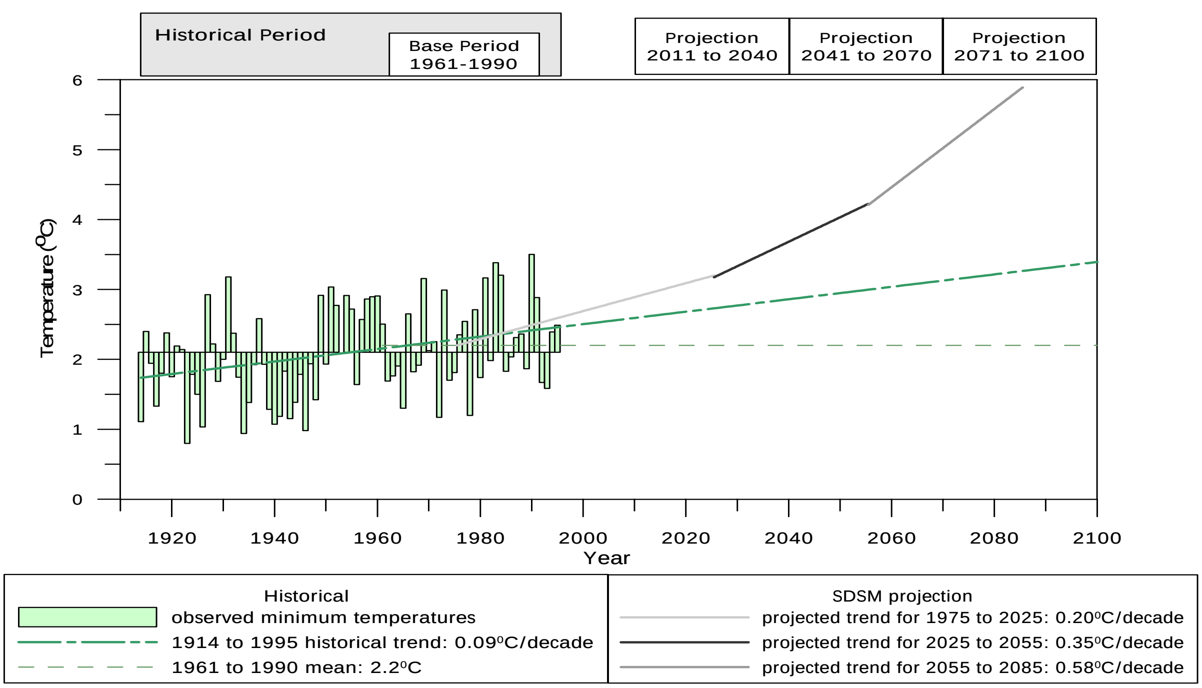

Figure III-2 Summary of historical and projected mean minimum temperature trends to 2100 in Kentville.

Where the sites differ is in the historical character of the maximum temperature. Kentville displayed a warming of about one-tenth of one degree per decade (Table III-4, Figure III-4); while Greenwood showed no trend (Table III-3, Figure III-3).

A difference in length of record for the two sites appears to be the main reason for differences in the magnitude of observed trends in maximum and minimum temperature from one site to the next. Greenwood has data for only 57 years compared to Kentville with a record of 82 years.

Table III-3 Summary of historical and projected trends and values for average annual maximum temperature (Tmax) in Greenwood. Mean Tmax for base period 1961-1990 was 12.0°C (285.2K).

Decadal Trends		Projected Change from 1961-1990		
Period	Trend (°C/decade)	Period	Change (expressed as °C)	Change (expressed as %)
1943 to 1999	no trend			
1975 to 2025	0.4	2011 to 2040	1.8	0.6
2025 to 2055	0.5	2041 to 2070	3.3	1.1
2055 to 2085	0.7	2071 to 2100	5.4	1.9

Table III-4 Summary of historical and projected values and trends for average annual maximum temperature (Tmax) in Kentville. Mean Tmax for base period was 11.5°C (284.7K).

Decadal Trends		Projected Change from 1961-1990		
Period	Trend (°C/decade)	Period	Change (expressed as °C)	Change (expressed as %)
1914 to 1995	0.1			
1975 to 2025	0.4	2011 to 2040	1.9	0.7
2025 to 2055	0.5	2041 to 2070	3.3	1.1
2055 to 2085	0.7	2071 to 2100	5.4	1.9

Projected trends in annual average maximum (Tmax) and minimum (Tmin) temperature showed that by the 2020's, Tmax was warming at twice the rate of Tmin (0.4°C/decade *vs*. 0.2°C/decade); that by the 2050's, Tmax was warming at 1.2 times the rate of Tmin (0.5°C/decade *vs*. 0.4°C/decade); and that by the 2080's, Tmax was warming at 1.2 times the rate of Tmin (0.7°C/decade *vs*. 0.6°C/decade). Although temperatures are projected to continue increasing at an accelerated rate throughout the 21st century, the ratio in the projected trends for Tmax *vs*. Tmin is expected to level off. Furthermore, the ratio in the projected temperature trends is greater than the historical trend ratio, found earlier by Sutherland and Lines (Personal communication). They reported that, based on their analysis of 100 years of historical records at 5 sites in Nova Scotia, Tmin was warming at the same rate as Tmax.

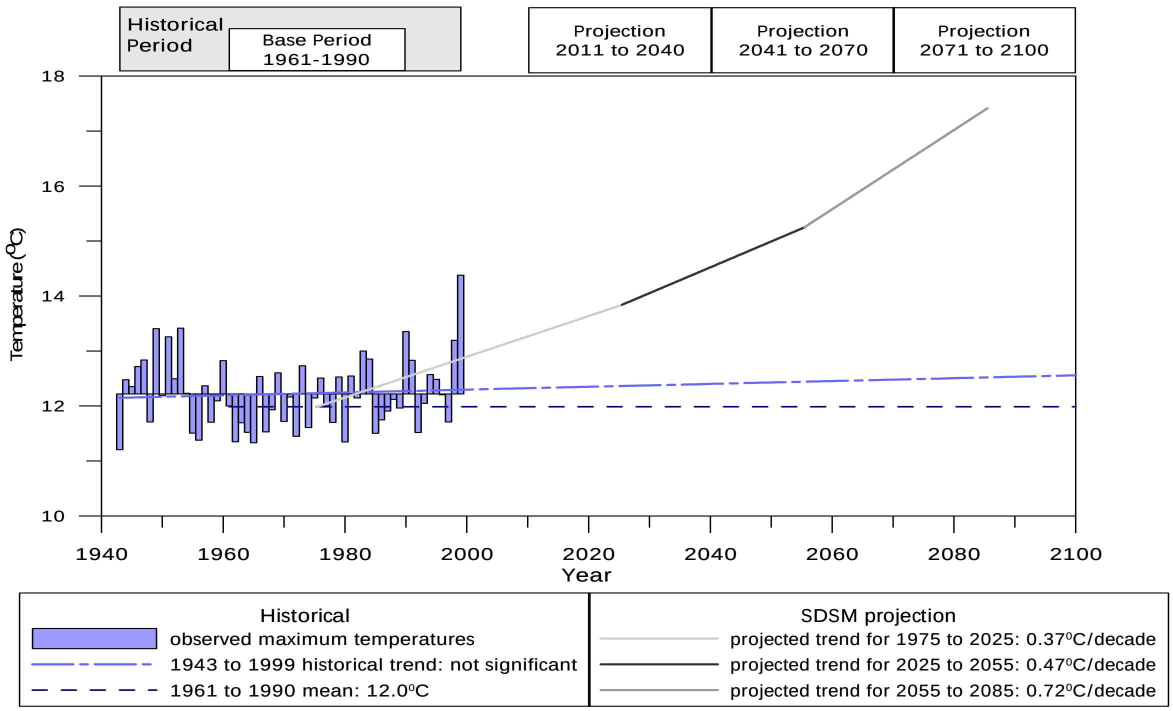

Figure III-3 Summary of historical and projected mean maximum temperature trends to 2100 in Greenwood.

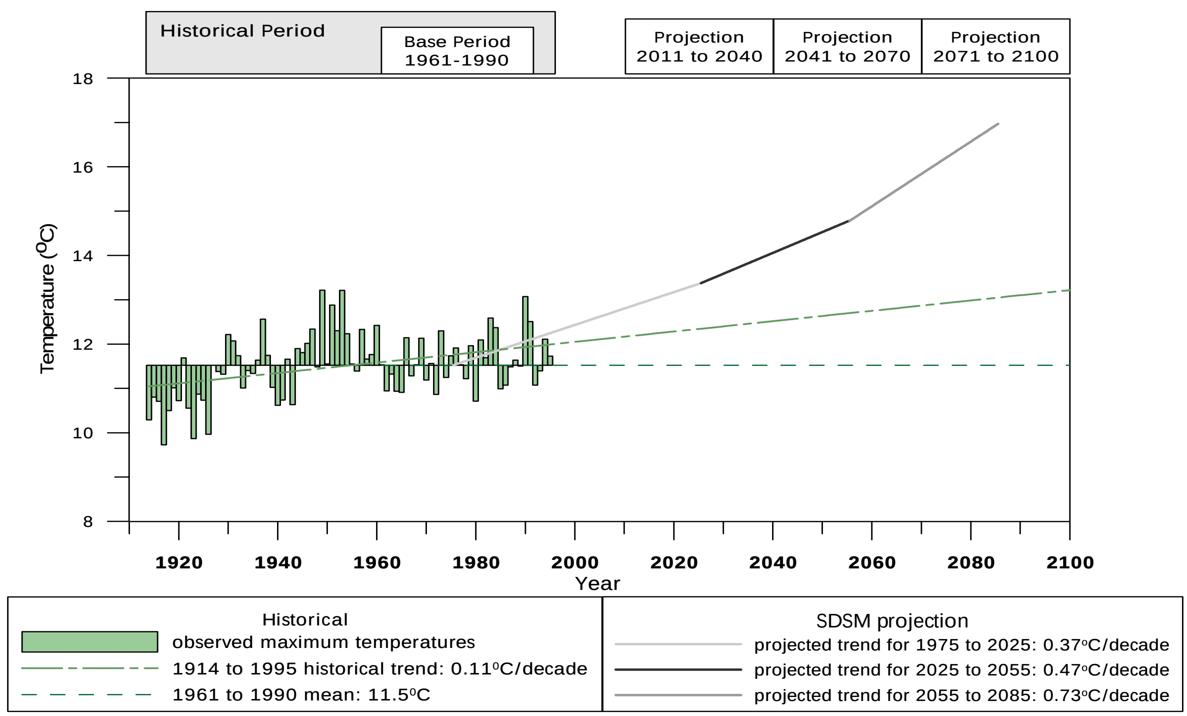

Figure III-4 Summary of historical and projected mean maximum temperature trends to 2100 in Kentville.

Warming of minimum temperatures is projected at both sites to be almost 4 degrees C by the end of the century (Tables III-1 and III-2). Such warming lessens the occurrence of frost by about 10% on an annual basis (Tables II-4 and II-7), but exacerbates the problem of heat stress. When a heat event occurs (i.e. extended period of hot days) the minimum temperature or "overnight low" can play a significant role in ameliorating the impact of the hot daytime temperatures. As projected, that amelioration effect will lessen with time, eventually leading to a situation where the "overnight low" would provide little relief from the daytime heat (Environment Canada, 1997).

Both sites are projected to have higher maximum temperatures, warming by as much as 5.4 degrees C over the next century (Tables III-3 and III-4). This will increase the number of hot days (> 25 degrees C) by almost 50% in the summer at both locations and extremely hot days (>30 degrees C) will also increase by around 50% (Tables II-4 and II-7). Such warming will increase heat stress on biological systems and potentially increase the demand for air conditioning. Air pollution, specifically smog, will be exacerbated by increased maximum temperature due to the reliance of smog production on warmer temperatures (IPCC, 2001). Populations at risk from increased smog may have to suffer through the combined effect of higher daytime temperatures and higher pollution levels.

A warming of either or both the minimum and maximum temperatures implies a warming of the mean temperature. Such warming can have the beneficial effect of extending growing seasons. However, since most growing systems require water as well as heat to prosper, changes to available precipitation will have an impact.

1.2 Precipitation

Trends of precipitation amount over the period of record were quite different at the two sites (Tables III-5 and III-6; Figures III-5 and III-6). Kentville displayed a trend of almost 26mm per decade increase in annual precipitation amounts while Greenwood showed 8.5mm per decade. Little importance should be placed on this difference when interpreting its impact, since the sites have data records of different lengths.

What is noticeable is the similarity in the projected change in amount above the base climate period (1961-1990). Projections for both sites exhibited a 10-15% increase in amount out to 2100 (Tables III-5 and III-6). The projections showed that, once the precipitation amount increased in the first tri-decade, it maintained that level of change for the remainder of the century (Figures III-5 and III-6).

Table III-5 Summary of historical and projected values and trends for average annual precipitation amounts (Pcpn) in Greenwood. Mean Pcpn for base period 1961-1990 was 1100 mm/year.

Decadal Trends		Projected Change from 1961-1990		
Period	Trend (mm/decade)	Period	Change (expressed in mm)	Change (expressed as %)
1943 to 2000	8.5			
1975 to 2025	26.8	2011 to 2040	134	12
2025 to 2055	1.7	2041 to 2070	139	13
2055 to 2085	-8.3	2071 to 2100	114	10

Table III-6 Summary of historical and projected values and trends for average annual precipitation amounts (Pcpn) in Kentville. Mean Pcpn for base period 1961-1990 was 1206 mm/year.

Decadal Trends		Projected Change from 1961-1990		
Period	Trend (mm/decade)	Period	Change (expressed in mm)	Change (expressed as %)
1914 to 2000	25.7			
1975 to 2025	36.4	2011 to 2040	182	15
2025 to 2055	-8.3	2041 to 2070	157	13
2055 to 2085	8.3	2071 to 2100	182	15

By season, both sites showed precipitation increases in the summer, autumn and winter; with little change in the spring (Greenwood; Figure II-6) or a decrease in spring (Kentville; Figure II-5).

Projected change in precipitation amount does not provide the full picture of changes expected in the precipitation regime of the Annapolis Valley. Examination of the nature of the precipitation, as described by the number of wet and dry days and extreme amounts, is also important. In the case of the percentage of wet days, both sites exhibited a decrease in the winter by as much as 14% (Tables II-10 and II-13). This implies that, even though the winter months will see more precipitation, there will also be fewer days on which precipitation will occur.

These projected seasonal changes imply heavier precipitation on fewer days in winter and less precipitation in spring, potentially impacting climate-sensitive sectors of the economy, such as agriculture.

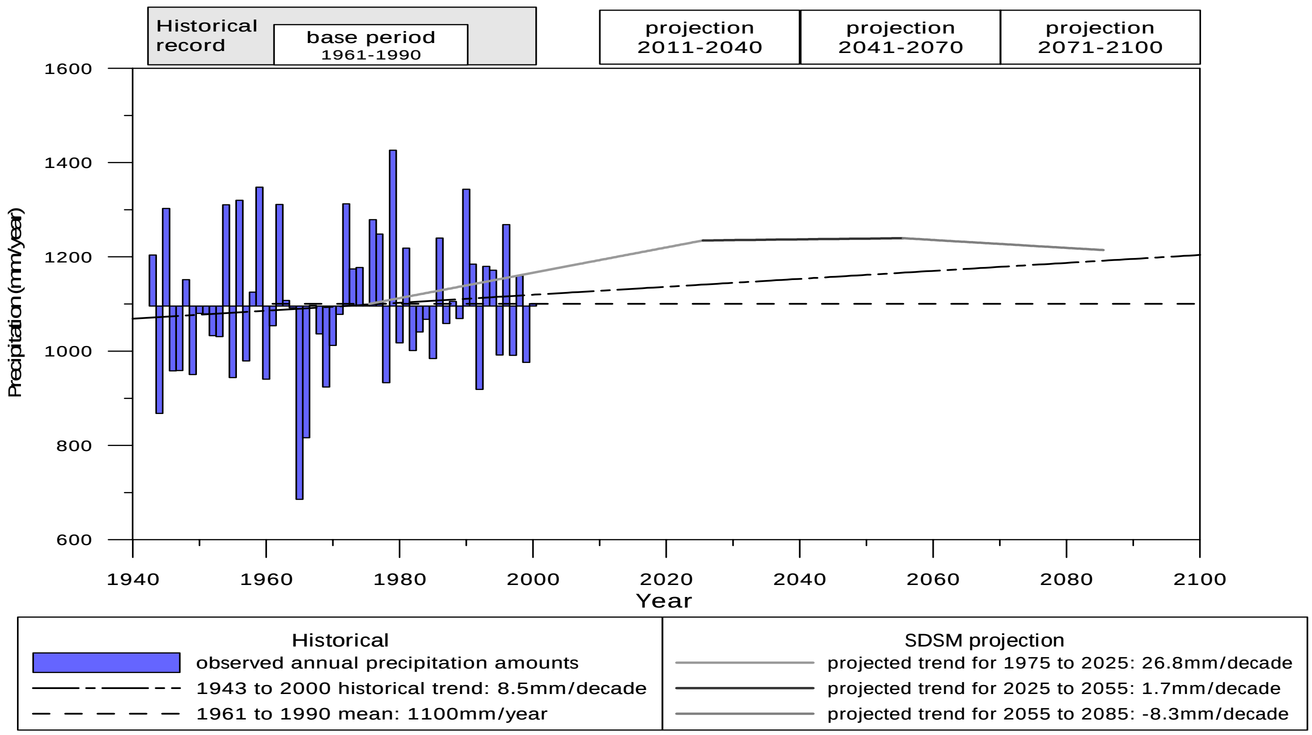

Figure III-5 Summary of historical and projected average annual precipitation trends to 2100 in Greenwood.

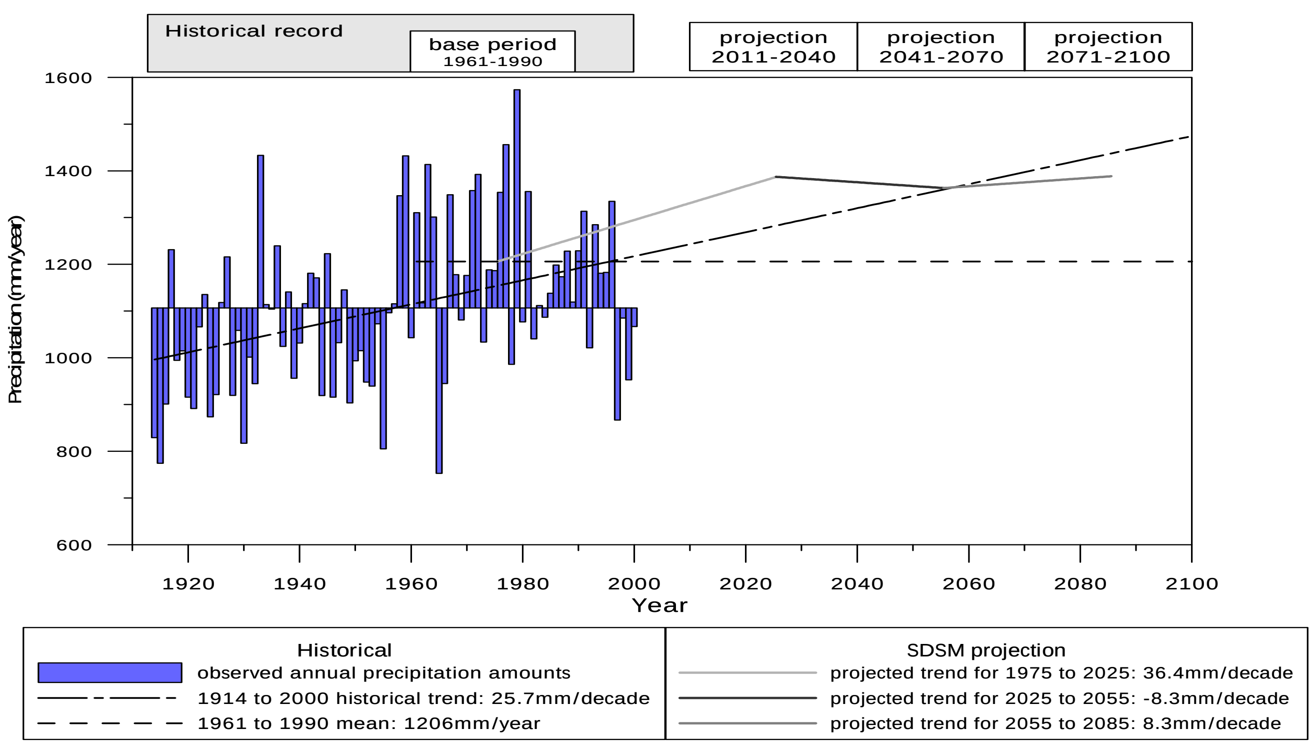

Figure III-6 Summary of historical and projected average annual precipitation trends to 2100 in Kentville.

1.3 Other Climate Variables and Implications

This study was not a full accounting of all the climate variables. While it does provide an initial look at a plausible future climate in the Annapolis Valley and the implications of projected changes there, there are other climate-related variables that could interest stakeholders and are not covered explicitly by this study.

They are:

- Sea Level Rise
- Growing Degree Days
- Heating and Cooling Degree Days
- Variation in stream flow in Annapolis Valley Rivers
- Moisture and Humidity Variables
- Rates of Evapotranspiration

And the following implications of changes to those variables:

- Increase in coastal flooding and erosion rates.
- Potential increase in growing season.
- Requirement for more space cooling (less heating).
- Change in growing environment for natural resources such as forests.
- Change in environment for fish habitat in Annapolis Valley Rivers.
- Change in environment for wildlife in the Annapolis Valley.
- Change in rates of evapotranspiration (as noted in BC conifers (Spittlehouse, personal communication))

Such impacts can be complex and require the combination of a number of variables (i.e. temperature and moisture) to identify them correctly. Further study will be required to expand our understanding of these impacts.

Section Two: References

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