Analysis of Trends in Evaporation – Phase 2

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Executive Summary

This study continues to explore gross and pan evaporation trends by examining the origins of trends. Control mechanisms examined include air temperature, wind speed, dew point temperature, water vapour pressure (V_w), air vapour pressure (V_a) and the difference between water vapour pressure and air vapour pressure (V_w-V_a). Trends were identified using the Mann-Kendall statistical test and bootstrap resampling for the 10% and 5% significance levels. Exploratory data analysis and correlations between variables were conducted to identify causal mechanisms in both gross and pan evaporation.

July has the highest percentage of decreasing gross evaporation trends in "Analysis of Trends in Evaporation: Phase 1" (Hesch and Burn, 2005) and is the only month to show field significant decreasing trends in wind speed and V_w-V_a for all three time periods. The only field significant increasing trends in gross evaporation (identified in "Analysis of Trends in Evaporation: Phase 1) occur in September for the 30-year period and April for the 50-year period. Both cases show a field significant increasing trend in V_w-V_a. It can be noted that wind speed showed field significant decreasing trends for every case in the 30, 40 and 50-year periods.

Gross evaporation trends were compared to trends in input variables. All variables showed the most common result was no significant trend for either. Air temperature, water vapour pressure and wind speed illustrated multiple cases of matching trends with gross evaporation, whereas dew point temperature and air vapour pressure showed opposing trends to be more common. These relationships are expected based on the calculations used to obtain the gross evaporation values.

Examining causal mechanisms for gross evaporation revealed that wind speed or V_w-V_a were typically the primary factor. The longer record lengths of 40 and 50-years indicated that wind speed generally has more of an influence in decreasing trends and V_w-V_a in increasing trends. Correlations with pan evaporation show that, typically, the causal mechanism is V_w-V_a. Measured values affecting V_w-V_a in these cases are both air temperature and dew point temperature or solely air temperature. Wind speed shows a notable correlation with gross evaporation, but correlations between wind speed and pan evaporation are generally low. Cases with relatively high correlations between pan evaporation and wind speed generally showed matching significant trends in pan and gross evaporation. Wind speed exerting an influence on gross evaporation and not pan evaporation was the typical explanation for discrepancies between pan and gross evaporation trends.

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1.0 Introduction

"Analysis of Trends in Evaporation: Phase 1" (Hesch and Burn, 2005) analysed trends in gross evaporation for three time periods dating from 1971 to 2000, 1961 to 2000 and 1951 to 2000. Different time periods provided unique results, but the June, July, October and annual evaporation produced field significant decreasing trends in the 30, 40 and 50-year periods. The longer record length for the 50-year period identified an increasing trend in April. The only other field significant increasing trend occurred for the 30-year period in September. The September results progressed into a significant decreasing trend as the record length increased. Mapping the location of significant monthly trends indicated that increasing trends were typically situated in the more northern regions and decreasing trends in the more southern regions.

Comparisons made in "Analysis of Trends in Evaporation: Phase 1" (Hesch and Burn, 2005) between gross evaporation trends and pan evaporation trends revealed many similar results, but most of these indicated no trend for either. Cases existed for both matching significant trends and opposing significant trends. Despite the existence of opposing significant trends, plots of pan and gross evaporation show similar timing of maximum and minimum values. Correlation values were calculated between pan and gross evaporation; a large range of values was found, 0.879 being the highest and 0.282 the lowest.

This study continues to explore gross and pan evaporation trends by examining the origins of the trends. Control mechanisms examined include air temperature, wind speed, dew point temperature, water vapour pressure (V_w), air vapour pressure (V_a) and the difference between water vapour pressure and air vapour pressure (V_w-V_a). All of these variables are used in the calculation of gross evaporation. Time periods and stations included were adapted to correspond with those used in Phase 1 of the investigation (Hesch and Burn, 2005). A listing of the stations can be found in Appendix A. Trend analyses were performed for all of the input variables at both the 10% and 5% significance level. Evaporation trends, identified at the 10% significance level in "Analysis of Trends in Evaporation: Phase 1" (Hesch and Burn, 2005), were reassessed at the 5% significance level as well. Results for input variables were examined for any unusual patterns and comparisons were made between variables to identify causal mechanisms in gross evaporation trends. Correlations between variables were also determined to help identify causal mechanisms and explore the relationship between pan and gross evaporation.

2.0 Methodology

Gross evaporation for this study is calculated using Meyer's formula. Meyer's formula, as outlined by Martin (2002), is presented in Equation (1):

$$EG = CK(V_w - V_a)(1 + 6.2139 \times 10^{-2}W)(1 + 3.28084 \times 10^{-5}A) \qquad (1)$$

where: EG = monthly gross evaporation, in millimetres, at the meteorological station,
C = coefficient of 11 if saturated vapour pressure is based on two observations of relative humidity per day; a coefficient of 10.1 if saturated vapour pressure is based on either two, four or 24

observations of dew point temperature per day; and a coefficient of 10.2 if saturated vapour pressure is based on three observations of dew point temperature per day,

K = metric conversion factor of 0.750062,

V_w = saturated vapour pressure, in millibars, corresponding to the estimated monthly mean water temperature at the surface of a hypothetical open body of water at the station site,

V_a = actual monthly mean vapour pressure, in millibars, in the atmosphere at 7.62 metres above the ground level at the station,

W = monthly mean wind speed, in kilometres per hour, at 7.62 metres above the ground level at the station, and

A = elevation, in metres above mean sea level, of ground level at the station.

Equation (1) illustrates that variables affecting gross evaporation include wind speed, water vapour pressure and air vapour pressure. Although air temperature and dew point temperature are not directly used in Equation (1), they are used to calculate water vapour pressure and air vapour pressure and, therefore, are also included in this study.

Adjustments were made to the available data to standardize or complete data sets. Several data were missing for dew point temperature in earlier years and had to be estimated using relative humidity. Also, for most stations, wind speed was recorded at various anemometer heights throughout the record lengths. A common height of 10 meters was designated for all stations and data were recalculated to allow an accurate identification of trends. The formula used to recalculate wind speed, as defined by Martin (2002), is presented in Equation (2):

$$W = W_r(10/H_{ag})^{0.25} \qquad \text{(2)}$$

where: W = monthly mean wind speed, in kilometres per hour, at 10 metres above ground level,

W_r = recorded monthly mean wind speed, in kilometres per hour, at the meteorological station, and

H_{ag} = height above ground, in metres, of the anemometer with which W_r observations were obtained.

For the data available for Phase 1 of this study, gross evaporation was assumed to be zero when the monthly mean surface water temperature was less than zero. As the model does not use water vapour pressure in these cases, the water vapour pressure values were considered unknown (missing) in such time intervals for the purposes of evaluating trends. An assessment of annual trends for variables was based on the mean value from April to October. An exception occurs for gross evaporation, which employs a sum. Months were not analysed if there were more than four years with missing data. Trends in variables were identified using the Mann-Kendall statistical test. Bootstrap resampling was employed to establish if trends were field significant. Refer to Hesch and Burn (2005) for complete documentation of the trend analysis methods used.

The relationship between pan evaporation and gross evaporation was further investigated for 12 stations. Refer to Appendix B for details of the stations included. Correlations were calculated between input variables and pan evaporation as well as input variables and gross evaporation. These correlation values were used to identify causal mechanisms in pan evaporation and to further explore the principle factors affecting gross evaporation.

3.0 Results

3.1 Analyzing Trend Results

Variable trends were assessed on a monthly basis for April through October and for the mean of the seven months included in this study. The mean was calculated for each year and was considered unknown (missing) if there were one or more months with missing data.

3.1.1 Air Temperature

Results for the analysis of air temperature using a 10% significance level and 30-year record are listed in Table 1.

Table 1: Percentage of stations with air temperature trends from 1971-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	0.00%	0.00%	4.17%	12.50%	10.42%	8.33%	0.00%	10.42%
Decreasing	0.00%	2.08%	0.00%	0.00%	0.00%	0.00%	16.67%	0.00%
No trend	100.00%	97.92%	95.83%	87.50%	89.58%	91.67%	83.33%	89.58%

Table 1 illustrates few air temperature trends in the 30-year period. April exhibits no trends and October has the highest percentage of trends at 16.67%. October and May show decreasing trends, while June through September and mean monthly temperature show increasing trends. Those months displaying trends are only increasing or only decreasing. Bootstrap resampling was performed to identify field significant trends, but none were found. A summary of trends at each station for the 10% and 5% level was documented and can be found in Appendix C and Appendix D, respectively. The highest number of trends at any one station (Table C1) occurs at Gillam, where five of the seven determinate cases are increasing trends. Decreasing trends are dispersed throughout the stations, with each station displaying no more than one decreasing trend. Trends at a 5% significance level were also examined for each variable and are listed in Appendix E. Similar to Table 1, the 5% significance level (Table E1) produced no field significant air temperature trends in the 30-year period. June, July, August and October are the only months to have significant trends at the 5% level and all are increasing except for October. All stations are limited to one or no significant trends, with the exception of Churchill (Table D1). Two of the seven determinate cases at Churchill exhibit increasing trends.

The 40-year period trends for air temperature were studied at a 10% significance level. Results are summarized in Table 2. The longer record length of 40 years reveals more trends than observed in the 30-year period. April, showing no trends in the 30-year period, has 31.43% of stations exhibiting an increasing trend. The percentage of stations with trends in October increases from 16.67% in the 30-year period to 66.67% in the 40-year period. Consequently, October has the highest percentage of stations showing trends, all of which are decreasing. Field significant trends identified using bootstrap resampling are highlighted in Table 2. It can be observed that October is the only month with a field significant trend at the

10% level. June and September show no trends in the 40-year period, although the same significance level in the 30-year period showed a small percentage of increasing trends.

Table 2: Percentage of stations with air temperature trends from 1961-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	31.43%	11.11%	0.00%	2.78%	2.78%	0.00%	0.00%	16.67%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	66.67%	5.56%
No trend	68.57%	88.89%	100%	97.22%	97.22%	100%	33.33%	77.78%

Identifying stations with trends reveals a greater number with decreasing trends than those with increasing trends (Table C2). However, most stations with decreasing trends show only one decreasing trend. Based on the results in Table 2, this trend occurs in October for the majority of the stations. Stations with increasing trends show a range in the number of trends found from one to three. At the 5% significance level (Table E2), the 40-year period identifies April and October to be field significant. April is significantly increasing while October is significantly decreasing. Trends in July and August no longer exist at the 5% level. Similar to the 30-year period, a breakdown of trends at each station at the 5% level shows only one trend in most cases (Table D2). The exception occurs at Rocky Mountain House, with two decreasing trends and Whitecourt, with two increasing trends.

Air temperature trends at a 10% significance level for the 50-year period are illustrated in Table 3.

Table 3: Percentage of stations with air temperature trends from 1951-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	68.97%	6.67%	30.00%	3.33%	0.00%	0.00%	0.00%	30.00%
Decreasing	0.00%	0.00%	0.00%	3.33%	0.00%	0.00%	40.00%	0.00%
No trend	31.03%	93.33%	70.00%	93.33%	100%	100%	60.00%	70.00%

Field significant trends in Table 3 are highlighted. April and June are both field significant with all increasing trends. It can be seen in Table 3 that April has the highest percentage of trends. Starting from the 30-year period, this percentage of increasing trends has grown progressively larger as the record period has lengthened. August behaves in an opposite manner by decreasing the number of trends as the record period lengthens. June and mean monthly temperature show a large increase in the percentage of trends from the 40-year period to the 50-year period. October has a smaller percentage of trends in the 50-year period than were observed for the 40-year period, causing it to no longer be field significant.

The 50-year period shows eight of 30 stations with three or more increasing air temperature trends (Table C3). The highest frequency of increasing trends occurs at Whitecourt with five increasing trends. Whitecourt, along with Calgary, Grande Prairie, Fort Nelson and Broadview, displayed an increasing number of increasing trends as the record length increased. Under half of the stations exhibit decreasing trends and Coronation is the only station to show more than one. Field significant trends at a 5% level (Table E3) were found for April, June, October and mean monthly temperature. April, June and mean monthly temperature are all increasing trends, while October is all decreasing. At the 5% significance level, September has not shown any air temperature trends for the record periods examined. The highest number of trends found at any station is three (Table D3). This occurs for five stations and trends are increasing in each case.

A study conducted by Zhang et al. (2000) also examined air temperature trends at the 5% significance level. Two time periods were examined, with 1950-1998 being the closest period to those studied in this report. Zhang et al. (2000) found spring, summer and annual daily maximum temperatures with increasing tendencies in the Canadian prairies. Most importantly, significant increasing trends in their study occur in spring or on an annual basis. Decreasing maximum temperatures were found in the fall, however, they were not found to be significant. Trends in minimum daily temperatures show a similar pattern to maximum daily temperatures.

The results from Zhang et al. (2000) are comparable to those found in this study. April, June and annual mean monthly temperature for the 50-year period have field significant increasing trends (at the 5% level) and are included, respectively, in the spring, summer and annual analyses conducted by Zhang et al. (2000). April shows the highest percentage stations with increasing trends, coinciding with spring having the most significant increasing trends. October, a component of the fall category, was found field significant with mostly decreasing trends. Although Zhang et al. (2000) did not find the decreasing tendencies in the prairies to be significant in fall, this could be due to the lack of trends in September, or possibly due to the behaviour of November, a month which was not included in this study.

3.1.2 Dew Point Temperature

Dew point temperature is also a factor that has an influence on gross evaporation. Trends in dew point temperature for the 30-year period from 1971-2000 are recorded at a 10% significance level in Table 4.

Table 4: Percentage of stations with dew point temperature trends from 1971-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	2.27%	2.08%	12.50%	62.50%	37.50%	22.92%	0.00%	31.25%
Decreasing	0.00%	2.08%	0.00%	0.00%	0.00%	0.00%	2.08%	0.00%
No trend	97.73%	95.83%	87.50%	37.50%	62.50%	77.08%	97.92%	68.75%

All months and mean monthly dew point temperature in Table 4 show stations with trends. However, only July, August and mean monthly dew point temperature are field significant. All cases of field significant trends are increasing. The highest percentage of trends occurs in July with 62.50% of stations exhibiting an increasing trend. Only a small percentage of stations in October and May indicate a decreasing tendency in dew point temperature. Comparable to the study of air temperature trends (Table 1 through Table 3), the majority of the months in Table 4 show only increasing or only decreasing trends. Only two stations were found to have decreasing trends, both of which have a frequency of one (Table C4). In contrast, 34 stations have increasing trends ranging from one to five trends. At a 5%

significance level the same cases have field significant trends as seen for the 10% level: July, August and mean monthly dew point temperature (Table E4). April and October are reduced to no trends at the 5% level. The number of stations with increasing trends is decreased from 34 to 22, with only two stations having a frequency above three (Table D4). The only station to display a decreasing trend is Nipawin.

Table 5 lists the results for dew point temperature trends from 1961-2000 at the 10% significance level.

Table 5: Percentage of stations with dew point temperature trends from 1961-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	2.86%	16.67%	11.11%	36.11%	19.44%	0.00%	0.00%	22.22%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	36.11%	0.00%
No trend	97.14%	83.33%	88.89%	63.89%	80.56%	100%	63.89%	77.78%

Similar to Table 4, the majority of the months in Table 5 illustrate stations with increasing trends. However, in most cases, the percentage of increasing trends is smaller in the 40-year period than in the 30-year period. This can be observed in July, August, September and mean dew point temperature. Despite a reduction in percentage of trends, July remains field significant in the 40-year period with all increasing trends. October is the only month in the 40-year period displaying a decreasing tendency. The percentage of stations showing a decreasing trend (at the 10% level) increased from 2.08% in the 30-year period to 36.11% in 40-year period. As a result, October exhibits a field significant trend in the 40-year period.

The number of stations with decreasing trends has risen from the results in the 30-year period, but none exceed a frequency of one decreasing trend (Table C5). This is expected after observing that a high percentage of decreasing trends only exists in October. The aforementioned reduction in increasing trends results in several stations decreasing their frequency by up to three trends from that of the 30-year period. Only 16 of the 36 stations in the 40-year period show increasing trends. When examining the 5% significance level (Table E5), the percentage of decreasing trends in October is greatly reduced and therefore no longer field significant. This suggests that decreasing trends at many of the stations in October are not well-defined. July remains a field significant trend at the 5% level with 22.22% of stations demonstrating an increasing trend. Only 14 stations in total have trends at the 5% level, nine with increasing trends and five with decreasing trends (Table D5).

Trends for dew point temperature for the 50-year record at the 10% significance level are presented in Table 6.

Table 6: Percentage of stations with dew point temperature trends from 1951-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	3.45%	6.67%	13.33%	10.00%	0.00%	0.00%	0.00%	6.67%
Decreasing	0.00%	3.33%	0.00%	0.00%	0.00%	0.00%	46.67%	3.33%
No trend	96.55%	90.00%	86.67%	90.00%	100%	100%	53.33%	90.00%

Table 6 further confirms that a longer record length reduces the percentage of increasing trends for July, August and mean monthly dew point temperature. August no longer shows any trends in the 50-year period and July progressed from 62.50% of stations with increasing trends in the 30-year period to only 10% in the 50-year period. October continues to raise the number of decreasing trends with the lengthening of the record to 50 years. The trend remains field significant in the 50-year period. Similar to the 40-year period, this field significant trend for October is only present at the 10% level.

At the 5% level there were no field significant trends identified using bootstrap resampling methods (Table E6). Six stations display increasing trends at the 10% level, with two stations having four increasing trends (Table C6). These two stations, Whitecourt and Gimli, account for 67% of the increasing trends in Table 6. Decreasing trends are more dispersed, with 14 stations showing decreasing trends and the highest frequency at any one station being two. Although the number of trends declines at the 5% level, Whitecourt still maintains four increasing trends (Table D6).

3.1.3 Air Vapour Pressure

Air vapour pressure was also examined using Mann-Kendall statistical testing and bootstrap resampling. Calculations of air vapour pressure were based on dew point temperature values. Table 7 summarizes the 30-year air vapour pressure trends at the 10% significance level.

Table 7: Percentage of stations with air vapour pressure trends from 1971-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	2.27%	2.08%	14.58%	62.50%	37.50%	22.92%	2.08%	45.83%
Decreasing	0.00%	2.08%	0.00%	0.00%	0.00%	0.00%	2.08%	0.00%
No trend	97.73%	95.83%	85.42%	37.50%	62.50%	77.08%	95.83%	54.17%

Air vapour pressure trends in the 30-year period are highest in July with 62.50% of stations showing increasing trends. Bootstrap resampling indicates July, August and mean monthly air vapour pressure are field significant trends, all of which are increasing. April, May and October show few trends in Table 7. October and May are the only months to show a percentage of stations with decreasing trends. It can be noted that percentages of trends for air vapour pressure are extremely similar to those of dew point temperature, as dew point temperature is used in the calculation of air vapour pressure. Similarities can also be found in the trends displayed at each station (Table C7): only two stations have decreasing trends, both with a frequency of one and 34 stations show increasing trends with frequencies ranging from one to five. Although frequencies of increasing trends at each station vary slightly between the dew point temperature and air vapour pressure, they never differ by more than one trend.

At the 5% significance level (Table E7), April demonstrates no trends. All months show a reduction in the percentage of stations with trends. The largest monthly reduction, 16.67%, occurs in both July and August. July, August and mean monthly air vapour pressure continue to be field significant.

Table 8 illustrates the air vapour pressure trends for the 40-year period dating from 1961-2000.

Table 8: Percentage of stations with air vapour pressure trends from 1961-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	2.86%	16.67%	11.11%	41.67%	19.44%	0.00%	0.00%	33.33%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	38.89%	0.00%
No trend	97.14%	83.33%	88.89%	58.33%	80.56%	100%	61.11%	66.67%

The percentages of increasing trends in the 40-year period are generally less than those seen in the 30-year period. September no longer shows any trends in the 40-year period after 22.92% of stations were increasing in the 30-year period. A breakdown of trends at each station (Table C8) indicates that five stations account for nearly half of the increasing trends observed in Table 8. The transition to a longer record length increased the percentage of decreasing trends in October to 38.89%. As October is the only month displaying decreasing trends, it is appropriate that the decreasing trends are dispersed among the stations with no more than a frequency of one. July and mean monthly air vapour pressure continue to be field significant in Table 8 with all increasing trends. However, the reduction in percentage of increasing trends no longer qualifies August as field significant. A large increase in the percentage of decreasing trends in October registers it as field significant for the 40-year period, but only at the 10% level. At a 5% significance level (Table E8), only July and mean monthly air vapour pressure are field significant. As can be expected, the percentages of trends at the 5% level are reduced from the 10% level; the number of stations with increasing trends is decreased from 19 to 12 and the number of stations with decreasing trends is reduced from 14 to five (Table D8). The largest percentage of trends occurs in mean monthly air vapour pressure with 25%.

Trends for air vapour pressure at a 10% significance level dating from 1951-2000 are recorded in Table 9.

Table 9: Percentage of stations with air vapour pressure trends from 1951-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	3.45%	6.67%	13.33%	13.33%	0.00%	0.00%	0.00%	13.33%
Decreasing	0.00%	3.33%	0.00%	0.00%	0.00%	0.00%	43.33%	0.00%
No trend	96.55%	90.00%	86.67%	86.67%	100%	100%	56.67%	86.67%

Similar to the comparison between the 30 and 40-year trends, in most cases, the 50-year record decreases the number of increasing trends from those in the 40-year period. This is also supported in the summary of trends for each station in Table C9. The number of stations with increasing trends in the 50-year period is decreased, as well as the frequency at most stations. This suggests the increasing trend is more evident in recent years, while decreasing tendencies may exist earlier in the record. This pattern was also identified in the dew point temperature trends. Table 9 illustrates the only field significant trend occurs in October with 43.33% of stations demonstrating a decreasing trend. Despite October's decreasing tendency, mean monthly air vapour pressure shows no stations with decreasing trends. This indicates that stations with decreasing trends in October also have increasing tendency in other months to offset the decrease in October. At the 5% level (Table E9), October is also the only field significant trend with 16.67% of stations displaying a decreasing trend. The highest percentage of increasing trends, 6.67%, occurs for mean monthly air vapour pressure. The only stations to exhibit increasing trends at the 5% level are Whitecourt and Gimli (Table D9).

3.1.4 Water Vapour Pressure

Water vapour pressure plays a role in gross evaporation. Trends for the 30-year period at the 10% significance level are summarized in Table 10.

Table 10: Percentage of stations with water vapour pressure trends from 1971-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	0.00%	0.00%	4.17%	12.50%	10.42%	8.33%	0.00%	11.43%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.90%	2.86%
No trend	100%	100%	95.83%	87.50%	89.58%	91.67%	88.10%	85.71%

Water vapour pressures were calculated using air temperature values, so similarities can be seen between Table 1 and Table 10. There are no trends occurring in April or May. The highest percentage of trends is for mean monthly water vapour pressure, with most increasing. October has the largest percentage of stations with decreasing trends. The trends in Table 10 occur at 15 stations (Table C10). Ten stations have increasing trends and five have decreasing trends. The frequencies of trends vary for different stations, Gillam having the highest with four increasing trends. At the 5% level (Table E10) October is the only month with decreasing trends. August has the highest percentage of trends, all of which are increasing. Similar to the 10% level, there are no field significant trends at the 5% level.

From 1961-2000, water vapour pressure trends are as seen in Table 11.

Table 11: Percentage of stations with water vapour pressure trends from 1961-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	34.38%	11.43%	0.00%	2.78%	2.78%	0.00%	0.00%	15.63%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	70.59%	6.25%
No trend	65.63%	88.57%	100%	97.22%	97.22%	100%	29.41%	78.13%

The 40-year record shows a dramatic increase in the percentage of decreasing trends for October. April also increases from exhibiting no trends in the 30-year period, to having 34.38% of stations with increasing trends. Other cases show only moderate changes between the 30 and 40-year period. These changes reduce June and September to no trends. The majority of the stations have trends at the 10% level but only Peace River and Whitecourt exceed two trends (Table C11). This indicates that the percentages of trends observed in the 40-year period are not highly influenced by any one station. As highlighted in Table 11, October is the only month with a field significant trend. At the 5% significance level (Table E11), both April and October are field significant. Trends are less in all cases at the 5% level except the percentage of decreasing trends for mean monthly water vapour pressure. The largest number of trends at any station does not surpass two (Table D11). The months of June through September show no trends and May has only 2.86% of stations demonstrating trends (all increasing).

Trends for water vapour pressure in the 50-year period at the 10% level are presented in Table 12.

Table 12: Percentage of stations with water vapour pressure trends from 1951-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	65.38%	10.34%	30.00%	3.33%	0.00%	3.33%	0.00%	23.08%
Decreasing	0.00%	0.00%	0.00%	3.33%	0.00%	0.00%	42.86%	3.85%
No trend	34.62%	89.66%	70.00%	93.33%	100%	96.67%	57.14%	73.08%

April has increased the percentage of increasing trends with each record lengthening, becoming field significant in the 50-year period. June and October are also field significant trends; June demonstrates all increasing trends and October all decreasing trends. Other cases show various patterns as the record period lengthens. Mean monthly water vapour pressure develops a higher percentage of increasing trends (like April) and August develops lower percentages of increasing trends. Specific stations also exhibit patterns as the record length increases (Table C12). Edmonton Municipal, Whitecourt and Broadview all show more increasing trends with the longer analysis periods. At the 5% level (Table E12), April still displays the highest percentage of trends, all increasing. April, June and October remain field significant. July and September no longer show stations with significant trends and the only case of decreasing trends occurs in October.

3.1.5 The Difference between Water Vapour Pressure and Air Vapour Pressure

Meyer's formula (refer to Equation (1)) uses the difference between water and air vapour pressure (V_w-V_a) as an input variable to calculate gross evaporation. The 30-year trends for this variable at the 10% significance level are presented in Table 13.

Table 13: Percentage of stations with V_w-V_a trends from 1971-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	11.43%	2.13%	4.17%	0.00%	2.08%	18.75%	0.00%	8.57%
Decreasing	0.00%	2.13%	22.92%	41.67%	8.33%	6.25%	26.19%	45.71%
No trend	88.57%	95.74%	72.92%	58.33%	89.58%	75.00%	73.81%	45.71%

Trends in V_w-V_a are mostly decreasing. Although cases of increasing trends exist, the highest percentage for any month occurs in April with 11.43%. Three cases show field significance: June, July and mean monthly V_w-V_a. All three have mostly decreasing trends. The highest percentage of stations with trends occurs for mean monthly V_w-V_a, however, July is within a close proximity. When examining 30-year trends for air vapour pressure trends (Table 7), field significant increasing trends were found in July and for mean monthly air vapour pressure. No field significant trends were found in water vapour pressure 30-year trends (Table 10). This suggests that July and mean monthly V_w-V_a trends in Table 13 are being influenced by increasing air vapour pressure trends, causing the difference between water and air vapour pressure to decrease. The decreasing tendency of V_w-V_a is evident at many of the stations (Table C13); seven stations demonstrate four decreasing trends. At the 5% significance (Table E13) level June, July and mean monthly V_w-V_a remain field significant. Also, September becomes field significant at the 5% level. September is the only field significant case to have mostly increasing trends.

Trends in the difference between water and air vapour pressure for the 40-year period are summarized in Table 14.

Table 14: Percentage of stations with V_w-V_a trends from 1961-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	59.38%	5.71%	2.78%	0.00%	0.00%	13.89%	0.00%	9.38%
Decreasing	0.00%	0.00%	16.67%	52.78%	5.56%	0.00%	17.65%	15.63%
No trend	40.63%	94.29%	80.56%	47.22%	94.44%	86.11%	82.35%	75.00%

The percentages of trends in Table 14 are concentrated in April and July. Both months show over half of the stations with trends at the 10% level. The only month with field significance common to the 30 and 40-year periods is July. The percentage of trends in July increased slightly in the 40-year period, all of which are decreasing. Both June and mean monthly V_w-V_a are still mostly decreasing, but the percentage of stations with trends is greatly reduced for the 40-year period. A dramatic increase in the percentage of increasing trends between the 30 and 40-year period occurs in April. April jumps from 11.43% of stations with increasing trends in the 30-year period to 59.38% in the 40-year period. As a result, April is recognized as field significant. The rise of increasing trends in water vapour pressure from the 30 to 40-year period is one possible source of the jump in April increasing trends for V_w-V_a. It can be noted at the 10% level that field significant trends were recognized in October for water and air vapour pressure but not for V_w-V_a. October shows few trends for V_w-V_a in the 40-year period because the water and air vapour pressure trends are both moving in the same direction (decreasing), creating little impact on the difference between V_w-V_a. Stations with a high frequency of trends at the 10% level (Table C14) include Peace River and Prince Albert (increasing trends) as well as Gimli (decreasing trends). At the 5% significance level (Table E14) April and July remain the only field significant cases. Although there is an overall reduction in the percentages of trends, patterns remain similar at the 5% level to those seen in Table 14.

Table 15 illustrates trends in V_w-V_a for the 50-year period at the 10% level. It can be seen in Table 15 that increasing trends in April are becoming more dominant with the longer record length. The percentage of stations with increasing trends in the 50-year period reaches 84.62%, the highest percentage of trends observed in one month for any of the variables in this investigation. Similar to the 40-year period, a possible factor in April's high percentage of increasing trends are the increasing trends present in water vapour pressure. For the same record length, April water vapour trends are field significant and are all increasing. In addition to April, July V_w-V_a trends are also field significant in the 50-year period. The percentage of decreasing trends in July is decreased in the 50-year period from those seen in the 40-year period. Also, significant increasing trends became evident. Although July is still mostly decreasing, this is the first record to show increasing trends in this month for V_w-V_a. Looking back at V_w-V_a trends in the 30-year period (Table 13), decreasing trends are more common. However, the progression to the 50-year record shows more cases and higher percentages of increasing trends. This progression from decreasing to increasing trends is also present at various individual stations (Table C15), including Fort McMurray, Dauphin and Regina. Similar to the 30-year period, September is field significant only at the 5% level (Table E15). The change in significance level from 10% to 5% only caused a reduction of 3.33%, indicating that trend slopes in September are well defined. Similarities can also be drawn between the 30 and 50-year September trends in that they are mostly increasing trends.

Table 15: Percentage of stations with V_w-V_a trends from 1951-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	84.62%	24.14%	16.67%	10.00%	10.00%	23.33%	3.57%	7.69%
Decreasing	0.00%	0.00%	0.00%	33.33%	3.33%	0.00%	7.14%	3.85%
No trend	15.38%	75.86%	83.33%	56.67%	86.67%	76.67%	89.29%	88.46%

3.1.6 Wind Speed

Trends in wind speed were examined for the 30, 40 and 50-year periods. Results for the 30-year period at the 10% significance level are summarized in Table 16.

Table 16: Percentage of stations with wind speed trends from 1971-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	15.91%	14.58%	16.67%	8.33%	10.42%	18.75%	10.42%	18.75%
Decreasing	31.82%	31.25%	29.17%	45.83%	29.17%	31.25%	33.33%	43.75%
No trend	52.27%	54.17%	54.17%	45.83%	60.42%	50.00%	56.25%	37.50%

Table 16 illustrates a large number of trends found in wind speed behaviour. There is a presence of both increasing and decreasing tendencies for all months and mean monthly wind speed, but each case is mostly decreasing trends. Also, every case was found to be field significant using bootstrap resampling. The highest percentage of trends occurs for the mean monthly wind speed with 43.75% of stations displaying decreasing trends and 18.75% having increasing trends. The smallest percentage of trends occurs in August with 39.59% of stations having trends, 29.17% decreasing and 10.42% increasing. Thirty-three of the 48 stations possess decreasing trends for wind speed for the 30-year period (Table C16). Some stations only show one decreasing trend while others show all decreasing trends. Stations with increasing trends also show a range from one to all eight cases with increasing trends. Merely two stations do not show any trends and only Pincher Creek shows a combination of both increasing and decreasing trends. At the 5% significance level (Table E16) every month and the mean monthly wind speed were also found to be field significant. Some stations still display all eight cases with all increasing or all decreasing significant trends (Table D16). The number of stations showing no trends has risen from two at the 10% significance level to 15 at the 5% level.

The 40-year record length of wind speed reveals trends at a 10% significance level that are listed in Table 17.

Table 17: Percentage of stations with wind speed trends from 1961-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Decreasing	60.00%	55.56%	38.89%	55.56%	58.33%	52.78%	55.56%	72.22%
No trend	40.00%	44.44%	61.11%	44.44%	41.67%	47.22%	44.44%	27.78%

Wind speed trends from 1961-2000 are all decreasing. Every case, except for June, has 50% or more stations with a decreasing trend. Although the 30-year period also had a large number of trends, they were both increasing and decreasing trends. This discrepancy can be partially accredited to the elimination of stations with insufficient record length to be included in the 40-year period. Similar to the 30-year period, mean monthly wind speed continues to have the highest percentage of trends, as 72.22% of stations are decreasing. All months and mean monthly wind speed show an increase in the percentage of decreasing trends from the 30 to the 40-year period. The smallest increase occurs in June with a difference of 9.72%. Nine stations in the 40-year period have no wind speed trends and those with decreasing trends have a frequency of at least two (Table C17). Thirteen stations have all eight cases decreasing. Examining 40-year wind speed trends at the 5% significance level shows comparable results to the 10% level (Table E17). All months and mean monthly wind speed remain field significant. June and October do not show any change in the percentage of trends. The largest reduction in trends between the 10% and 5% level occurs for July and August with a change of approximately 8%. The number of stations showing no trend is increased to ten at the 5% level and the number of stations with all cases showing decreasing trends is 12 (Table D17).

Wind speed trends at the 10% significance level for the 50-year record are summarized in Table 18.

Table 18: Percentage of stations with wind speed trends from 1951-2000 (10% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	3.45%	3.33%	3.33%	3.33%	3.33%	3.33%	3.33%	3.33%
Decreasing	62.07%	60.00%	46.67%	66.67%	56.67%	60.00%	53.33%	73.33%
No trend	34.48%	36.67%	50.00%	30.00%	40.00%	36.67%	43.33%	23.33%

Table 18 illustrates higher percentages of trends for all months when comparing the 40 and 50-year period. Some of these increases are rather minor, at approximately 1%. However, each record lengthening consistently shows stronger indications of decreasing tendencies in wind speed, except August and October. Increasing trends reappear in the 50-year period. All months and mean monthly wind speed have approximately the same percentage of increasing stations. These percentages of increasing trends are mirrored at the 5% significance level for all cases except August (Table E18). August also shows the largest reduction in the number of decreasing trends (16.67%) between the 10% and 5% level. All months and mean monthly wind speed remain field significant at the 5% level. Similar to the 30 and 40-year period, several stations continue to show all decreasing trends at both the 10% and 5% level (Table C18 and Table D18). However, notable behaviour occurs at Peace River in the 50-year period. Peace River displayed minimal trends in the 30 and 40-year period. Despite this, the 50-year period shows eight cases with increasing trends at the 10% level and seven cases at the 5% level. Peace River is the only station displaying increasing trends for the 50-year period.

The irregularly high number of cases with field significant trends in wind speed raised concerns regarding the integrity of the data. Throughout the records, most stations were documented at various anemometer heights. If these changes in anemometer heights were improperly recorded by Environment Canada it could have potentially caused the identification of false trends. To investigate this possibility, wind speed data were plotted for stations that experienced changes in anemometer heights. Data were then explored at each of these stations to observe if any unusual behaviour occurred around the time the anemometer height was modified. Temporal trends were also examined and compared to the timing of changes in anemometer heights. Based on these studies, there was no substantial evidence found to indicate improper documentation of anemometer heights, or the identification of false trends in wind speed.

To further confirm the wind speed trend results, a study was conducted at stations that documented only the standardized 10 meter anemometer height within the required record lengths. The 50-year period was not analysed because there was an insufficient number of stations that met the criteria. The 30 and 40-year periods qualified 34 and 14 stations, respectively, for the study. At the 5% and 10% significance levels, both the 30 and 40-year time periods demonstrated field significant trends in every case. The study that only included stations with standardized anemometer heights generally had lower percentages of trends in the 30-year period and higher percentages of trends in the 40-year study. The difference in percentages of trends between the two studies was generally higher for the 40-year period and ranges up to 33%. The larger differences in the comparison of the 40-year studies may be a result of the small number of stations with standardized anemometer heights for the required record. Despite the discrepancies in exact percentages of trends, both studies support that there are field significant and mostly decreasing wind speed trends for every case.

3.1.7 Summary of Field Significant Trends

Table 19 summarizes all field significant cases in the 30-year period for gross evaporation and input variables. An arrow indicates field significance and the direction represents the majority of the trends for that case. Wind speed and V_w-V_a cases are highlighted if their field significance reflects the behaviour of field significant cases for gross evaporation.

Table 19: Summary of cases with field significance for 30-year period

Month	Gross evaporation		Air temperature		Dew point temperature		Air vapour pressure		Water vapour pressure		Wind Speed		V_w-V_a	
	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%
Apr	--	--	--	--	--	--	--	--	--	--	↓	↓	--	--
May	--	--	--	--	--	--	--	--	--	--	↓	↓	--	--
Jun	↓	↓	--	--	--	--	--	--	--	--	↓	↓	↓	↓
Jul	↓	↓	--	--	↑	↑	↑	↑	--	--	↓	↓	↓	↓
Aug	↓	↓	--	--	↑	↑	↑	↑	--	--	↓	↓	--	--
Sep	↑	↑	--	--	--	--	--	--	--	--	↓	↓	--	↑
Oct	↓	↓	--	--	--	--	--	--	--	--	↓	↓	--	--
Ann	↓	↓	--	--	↑	↑	↑	↑	--	--	↓	↓	↓	↓

April and May have no field significant trends for any variable except wind speed (which is field significant in all cases). September is the only field significant case that is increasing for gross evaporation. Examining the input variables for September reveals a decreasing wind speed trend at the 10% level and opposing trends between wind speed and V_w-V_a at the 5% level. Of these opposing trends, V_w-V_a displays the same increasing behaviour as gross evaporation. The relationships between variables are evident in July and annual trends. Dew point temperature trends for these cases are field significant and increasing. The same increasing trends are reflected in air vapour pressure, as it is calculated from dew point temperature. An increasing trend in air vapour pressure then causes a decreasing trend in difference between water and vapour pressure (V_w-V_a).

A summary of field significant trends in the 40-year period is presented in Table 20.

Table 20: Summary of cases with field significance for 40-year period

Month	Gross evaporation		Air temperature		Dew point temperature		Air vapour pressure		Water vapour pressure		Wind Speed		V_w-V_a	
	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%
Apr	--	--	--	↑	--	--	--	--	--	↑	↓	↓	↑	↑
May	--	--	--	--	--	--	--	--	--	--	↓	↓	--	--
Jun	↓	↓	--	--	--	--	--	--	--	--	↓	↓	--	--
Jul	↓	↓	--	--	↑	↑	↑	↑	--	--	↓	↓	↓	↓
Aug	↓	↓	--	--	--	--	--	--	--	--	↓	↓	--	--
Sep	--	--	--	--	--	--	--	--	--	--	↓	↓	--	--
Oct	↓	↓	↓	↓	↓	--	↓	--	↓	↓	↓	↓	--	--
Ann	↓	↓	--	--	--	--	↑	↑	--	--	↓	↓	--	--

Table 20 illustrates that October is field significant and decreasing at the 10% level for all variables except V_w-V_a. This is expected as the same decreasing tendency in water vapour pressure and air vapour pressure may cause the difference between the two to remain the same. In cases of field significant trends for gross evaporation, most cases show wind speed with matching trends. The only match between field significant trends for V_w-V_a and gross evaporation is in July. Opposing field significant trends occur between V_w-V_a and wind speed in April.

In the 50-year period the opposing field significant trends still exist between wind speed and V_w-V_a in April. However, gross evaporation trends become field significant in April and are increasing, similar to V_w-V_a. Details are illustrated in Table 21.

Table 21: Summary of cases with field significance for 50-year period

Month	Gross evaporation		Air temperature		Dew point temperature		Air vapour pressure		Water vapour pressure		Wind Speed		V_w-V_a	
	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%
Apr	↑	↑	↑	↑	--	--	--	--	↑	↑	↓	↓	↑	↑
May	--	--	--	--	--	--	--	--	--	--	↓	↓	--	--
Jun	↓	↓	↑	↑	--	--	--	--	↑	↑	↓	↓	--	--
Jul	↓	↓	--	--	--	--	--	--	--	--	↓	↓	↓	↓
Aug	--	--	--	--	--	--	--	--	--	--	↓	↓	--	--
Sep	↓	↓	--	--	--	--	--	--	--	--	↓	↓	--	↑
Oct	↓	↓	--	↓	↓	--	↓	↓	↓	↓	↓	↓	--	--
Ann	↓	↓	--	↑	--	--	--	--	--	--	↓	↓	--	--

The percentage of increasing trends in April for V_w-V_a increased with longer records (refer to Table 13, Table 14 and Table 15). Gross evaporation in April also exhibited this pattern. Therefore, the field significant trend in gross evaporation in April may have only occurred in the 50-year period because of the influence of V_w-V_a. It took the longer record length, and corresponding greater power of the statistical trend test, to identify the high percentage of V_w-V_a increasing trends. In the longer time period, these trends are strong enough to overcome the influence of opposing trends in wind speed. May and August show no field significant trends in the 50-year period except wind speed. This behaviour is consistent for May throughout all three time periods.

September shows the same pattern in field significant trends for wind speed and V_w-V_a as observed in the 30-year period, except this time, the combination results in a significant decreasing trend in gross evaporation. The progression of a significantly increasing trend in the 30-year period to significantly decreasing trend in the 50-year period may be a result of behaviour in wind speed. In September, the percentage of wind speed decreasing trends increases with longer record lengths (refer to Table 16, Table 17 and Table 18), as does the gross evaporation decreasing trends ("Analysis of Trends in Evaporation: Phase 1", (Hesch and Burn, 2005)). Therefore, the longer record length in September causes the percentage of decreasing trends to surpass those of increasing trends, resulting in a mostly decreasing field significant trend in the 50-year period. It is possible that the magnitude of trend slopes may have also influenced the behaviour of gross evaporation trends. The wind speed trend slopes may have been stronger in magnitude for the 50-year period, or the V_w-V_a trend slopes may have been weaker. It can be noted that, in the case of September, the influence of V_w-V_a increasing trends on the behaviour of gross evaporation increasing trends is not entirely understood. In gross evaporation, the highest percentage of September increasing trends occurs in the 30-year period, and the 50-year percentage of increasing trends is approximately half of this value. The percentage of increasing trends in V_w-V_a, however, is highest in the 50-year period.

3.2 Comparisons of Variable Trends

In order to identify causes of trends in gross evaporation, trends for input variables and gross evaporation were compared. Behaviour was categorized and examined to determine the frequency of each type. Details of the results of this comparison are available in Appendix F.

The comparison of air temperature and gross evaporation (Table F1, Table F2 and Table F3) proved the most common result to be no trend for either variable. The highest number of matching significant trends was 25 and occurred in the 40 and 50-year periods. In the 40-year period most of the matching significant trends were decreasing, but in the 50-year period they were mostly increasing. The 40-year period revealed one case of opposing significant trends. In examples where one variable possessed a trend while the other did not, it was most common for a decreasing trend in gross evaporation and no trend in air temperature. This was consistent for all three time periods.

Similar to air temperature, the most common type of behaviour when comparing dew point temperature and gross evaporation (Table F4, Table F5 and Table F6) was neither variable displaying a trend. Very few matching significant trends existed for any of the time periods. The highest frequency was in both the 40 and 50-year record with three cases of matching decreasing trends. When only one significant trend was present between the two variables, it was most often a decreasing trend for gross evaporation. Opposing significant trends appeared to be more common in this comparison; the 30-year period presented 44 cases of opposing significant trends. Forty-three of these cases have an increasing trend for dew point temperature and a decreasing trend for gross evaporation. The high number of opposing trends is to be expected based on the relationship between dew point temperature and gross evaporation. As dew point temperature increases, air vapour pressure, which is calculated from dew point temperature, also increases. An increase in air vapour pressure causes a decrease in the difference between water and air vapour pressure, resulting in decreasing trends in gross evaporation.

Comparisons were also made between air vapour pressure and gross evaporation trends (Table F7, Table F8 and Table F9). The percentage of opposing significant trends between air vapour pressure and gross evaporation becomes smaller the larger the record length. For the 30-year period approximately 13% of cases are opposing significant trends and the 50-year period has only 4% of cases with opposing significant trends. For each time period, the majority of the opposing trends have an increasing trend for air vapour pressure and a decreasing trend in gross evaporation. Again, this is due to the relationship between air vapour pressure and gross evaporation. The increase in air vapour pressure decreases V_w-V_a, resulting in a decreasing trend in gross evaporation. The most frequent behaviour is where neither variable displays a trend.

All three time periods show only one case of opposing trends when comparing water vapour pressure and gross evaporation (Table F10, Table F11 and Table F12). The highest number of examples for matching significant trends occurs in the 40-year period with 24 cases. The most common behaviour, similar to most other comparisons, is both variables displaying no trend. In addition, when one variable possesses a trend and the other does not it is most frequent to see a decreasing trend in gross evaporation and no trend in water vapour pressure.

Air vapour pressure and water vapour pressure variables are derived from dew point temperature and air temperature, respectively. Comparisons were made between air vapour pressure and dew point temperature as well as water vapour pressure and air temperature. Results for these comparisons are available in Appendix G. The comparison of air vapour pressure and dew point temperature revealed most trends were matching. Matching trends include when both variables have: no significant trend, decreasing significant trends or increasing significant trends. In several cases a significant trend occurred for only one variable. The most frequent example of this is an increasing trend in air vapour pressure with no trend in dew point temperature. Comparisons between water vapour pressure and air temperature generated similar results in that the majority of the cases were matching trends. However, slightly more cases were produced where a significant trend only exists for one variable. In general, the probabilities of both variables are within a close range, even in cases where a trend exists for one variable but not the other.

Wind speed and gross evaporation trend comparisons (Table F13, Table F14 and Table F15) provide unique results with respect to the aforementioned comparisons. The number of cases with no trend for either variable is relatively lower. Although it is still the most repeated type of behaviour in the 30 and 40-year period, cases with decreasing trends in wind speed and no trend in gross evaporation are more frequent in the 50-year period. Examples of matching trends are relatively high with approximately 90 cases in the 30 and 40-year period and almost 60 in the 50-year period. The highest number of opposing significant trends is 12 and occurs in the 50-year period.

Comparisons between air vapour pressure, water vapour pressure and gross evaporation revealed little information on the control mechanisms involved in gross evaporation trends. However, the difference between water vapour pressure and air vapour pressure provided insight into gross evaporation trends. A comparison was made between gross evaporation, the difference between water and air vapour pressure and wind speed. In cases where gross evaporation trends existed, a study was performed to determine if the difference between water and air vapour pressure (V_w-V_a) or wind speed was the causal mechanism.

Results for the 30-year period are summarized in Table 22. Potential causal mechanisms listed are the difference between water and air vapour pressure (V_w-V_a), wind speed, neither, or both. The "neither" heading represents cases where the significant trend in gross evaporation was not replicated in wind speed or V_w-V_a. However, all cases under the "neither" category showed the same slope tendencies in wind speed and V_w-V_a that were observed in the gross evaporation trend. The category labelled "both" represents cases where both wind speed and V_w-V_a have the same significant trend as the one observed in gross evaporation. The 30-year period suggests that wind speed has the largest influence on trends. Fifty-two cases indicate that wind speed is the causal mechanism and 38 cases show both mechanisms with trends of the same behaviour as gross evaporation. The results in Table 22 were categorized on a monthly basis. Table 23 illustrates the outcome.

Table 22: Causal mechanisms for 30-year gross evaporation trends (10% level)

Causal Mechanism	Gross evaporation trend	
	Increasing	Decreasing
V_w-V_a	10	20
Wind speed	14	38
Neither	0	11
Both	5	33
Total number of trends	29	102

Table 23: Causal mechanisms for 30-year gross evaporation trends on a monthly basis (10% level)

Month	Gross evaporation trend	Causal Mechanism			
		V_w - V_a	wind speed	neither	both
Apr	Increasing	3	1	0	1
	Decreasing	0	1	0	0
May	Increasing	1	2	0	0
	Decreasing	0	3	2	0
Jun	Increasing	0	3	0	1
	Decreasing	4	4	3	6
Jul	Increasing	0	1	0	0
	Decreasing	5	3	1	13
Aug	Increasing	0	1	0	1
	Decreasing	1	9	2	0
Sep	Increasing	5	3	0	2
	Decreasing	0	6	0	0
Oct	Increasing	0	1	0	0
	Decreasing	6	6	3	5
Ann	Increasing	1	2	0	0
	Decreasing	4	6	0	9

Results in Table 23 illustrate that similar decreasing behaviour in wind speed and the difference between water and air vapour pressure have an influence on gross evaporation trends in July. Signs of this are also present in the annual trends. Increasing gross evaporation trends for the 30-year period in April and September are mostly affected by the difference between water and air vapour pressure. Although the difference between water and air vapour pressure influences decreasing trends in several cases, it is not the dominant driving force for any particular month. Wind speed appears to have a significant role in August decreasing trends, as nine cases display it as the causal mechanism. The same pattern is visible for April, May and September decreasing trends. Decreasing trends in months such as June and October show high variability in the causal mechanisms of gross evaporation trends.

The 40-year period also shows a high influence of wind speed on decreasing gross evaporation trends. Details are presented in Table 24.

Table 24: Causal mechanisms for 40-year gross evaporation trends (10% level)

Causal mechanism	Gross evaporation trend	
	Increasing	Decreasing
V_w-V_a	12	14
Wind speed	0	65
Neither	0	6
Both	0	23
Total number of trends	12	108

Sixty-five cases indicate that decreasing gross evaporation trends are a result of wind speed. Table 24 indicates a strong influence of the difference between water and air vapour pressure on increasing gross evaporation trends. All 12 cases of increasing gross evaporation trends show the difference between water and air vapour pressure to be the driving force. Analysis on a monthly basis is provided in Table 25.

Table 25: Causal mechanisms for 40-year gross evaporation trends on a monthly basis (10% level)

Month	Gross evaporation trend	Causal Mechanism			
		V_w-V_a	wind speed	neither	both
Apr	Increasing	9	0	0	0
	Decreasing	0	0	0	0
May	Increasing	1	0	0	0
	Decreasing	0	6	0	0
Jun	Increasing	0	0	0	0
	Decreasing	3	9	2	3
Jul	Increasing	0	0	0	0
	Decreasing	6	6	0	12
Aug	Increasing	0	0	0	0
	Decreasing	2	14	1	0
Sep	Increasing	2	0	0	0
	Decreasing	0	5	0	0
Oct	Increasing	0	0	0	0
	Decreasing	1	9	3	5
Ann	Increasing	0	0	0	0
	Decreasing	2	16	0	3

The difference between water and air vapour pressure has the largest effect in April; all nine gross evaporation trends in April are affected by this mechanism. The difference between water and air vapour pressure also affects increasing trends in May and September, but only at a few stations. The majority of the months, as well as annual gross evaporation, attribute a greater part of the decreasing gross evaporation trends to wind speed patterns. This is especially evident in August and on an annual basis. From 1961-2000, July continues to show both wind speed and the difference between water and air vapour pressure as the main causal mechanisms of decreasing gross evaporation trends.

The summary of causal mechanisms of gross evaporation trends from 1951-2000 are provided in Table 26.

Table 26: Causal mechanisms for 50-year gross evaporation trends (10% level)

Causal mechanism	Gross evaporation trend	
	Increasing	Decreasing
V_w-V_a	20	4
Wind speed	4	41
Neither	0	3
Both	2	10
Total number of trends	26	58

Evaluating Table 22, Table 24 and Table 26 shows that longer record lengths decrease the number of cases where neither wind speed nor the difference between water and air vapour pressure are causal mechanisms. Although the difference between water and air vapour pressure is still the leading mechanism of increasing evaporation trends, several cases reappear where the driving force is wind speed, or both factors. The absence of these cases in the 40-year period is explained by the fact that no increasing wind speed trends exist in the 40-year period. Wind speed trends in the 50-year period, similar to those in the 30 and 40-year period, are largely responsible for the decreasing gross evaporation trends observed. Further examination of the results is provided by means of a monthly summary in Table 27. As seen in the 30 and 40-year periods, increasing gross evaporation trends in April are predominantly affected by the difference between water and air vapour pressure. This pattern is more apparent the longer the record length examined. Wind speed continues to play a large role in the decreasing trends found in many months, as well as annual trends. July has progressed from being mostly influenced by both mechanisms to having an equal number of cases where both mechanisms and only wind speed are the driving force of decreasing evaporation trends.

Trends in the difference between water and air vapour pressure were further examined to determine if air vapour pressure or water vapour pressure was affecting the change. Potential causal mechanisms were identified as water vapour pressure, air vapour pressure or both water and air vapour pressure. Determining causal mechanisms for V_w-V_a was not based solely on significant trends in V_w and V_a. In some cases, neither V_w nor V_a had significant trends. The majority of these cases had opposing tendencies between V_w and V_a that caused the difference between them to be a significant trend. In the 30-year period, 35 of the 86 V_w-

V_a trends were considered to have causal mechanisms that were not significant trends. Details of the causal mechanisms for V_w-V_a trends in the 30-year period (at the 10% level) can be found in Table 28.

Table 27: Causal mechanisms for 50-year gross evaporation trends on a monthly basis (10% level)

Month	Gross evaporation trend	Causal Mechanism			
		V_w-V_a	wind speed	neither	both
Apr	Increasing	15	0	0	1
	Decreasing	0	0	0	0
May	Increasing	1	0	0	1
	Decreasing	0	3	0	0
Jun	Increasing	2	1	0	0
	Decreasing	0	5	1	0
Jul	Increasing	0	0	0	0
	Decreasing	3	7	0	7
Aug	Increasing	0	0	0	0
	Decreasing	1	4	0	0
Sep	Increasing	2	1	0	0
	Decreasing	0	6	0	0
Oct	Increasing	0	1	0	0
	Decreasing	0	7	2	2
Ann	Increasing	0	1	0	0
	Decreasing	0	9	0	1

Table 28: Causal mechanisms of 30-year V_w-V_a trends (10% level)

Causal mechanism	V_w-V_a trend	
	Increasing	Decreasing
Water vapour pressure (V_w)	9	10
Air vapour pressure (V_a)	2	44
Both	9	12
Total number of trends	20	66

Increasing trends in V_w-V_a for the 30-year period appear to be influenced more by water vapour pressure rather than air vapour pressure. Nine cases show water vapour pressure as the causal mechanism, in comparison with only two cases that display V_a as the causal mechanism. Air vapour pressure has more influence on decreasing V_w-V_a trends with 44 cases identifying it as the principle factor. A breakdown of causal factors on a monthly basis is provided in Table 29.

Table 29: Causal mechanisms for 30-year V_w-V_a trends on a monthly basis (10% level)

Month	V_w-V_a trend	Causal Mechanism		
		V_w	V_a	both
Apr	Increasing	1	1	2
	Decreasing	0	0	0
May	Increasing	0	1	0
	Decreasing	0	0	1
Jun	Increasing	1	0	1
	Decreasing	1	2	8
Jul	Increasing	0	0	0
	Decreasing	0	20	0
Aug	Increasing	1	0	0
	Decreasing	0	4	0
Sep	Increasing	4	0	5
	Decreasing	0	3	0
Oct	Increasing	0	0	0
	Decreasing	9	1	1
Ann	Increasing	2	0	1
	Decreasing	0	14	2

Nearly all cases where V_w is the principle factor for decreasing V_w-V_a trends appear for October. Influences of V_w on increasing trends are dispersed throughout the months; September is the most affected showing four cases. Air vapour pressure appears to have the largest influence on decreasing trends in July and on an annual basis. July indicates all 20 V_w-V_a trends as being influenced by V_a; this is the only month that shows the same principle factor for every trend. Decreasing trends in June are mostly due to opposing behaviour between V_w and V_a. Decreasing tendencies in water vapour pressure and increasing tendencies in air vapour pressure cause their difference to have significant decreasing trends.

Causal mechanisms of 40-year V_w-V_a trends are summarized in Table 30.

Table 30: Causal mechanisms of 40-year V_w-V_a trends (10% level)

Causal mechanism	V_w-V_a trend	
	Increasing	Decreasing
Water vapour pressure (V_w)	14	6
Air vapour pressure (V_a)	1	22
Both	15	10
Total number of trends	30	38

Similar to the 30-year period, V_w appears to play a more influential role on increasing trends and V_a on decreasing trends. The cases where both V_w and V_a are the causal mechanisms have increased proportionate to the total number of trends in V_w-V_a. Causal mechanisms that are more dominant in particular months are illustrated in Table 31.

Table 31: Causal mechanisms for 40-year V_w-V_a trends on a monthly basis (10% level)

Month	V_w-V_a trend	Causal Mechanism		
		V_w	V_a	both
Apr	Increasing	10	0	9
	Decreasing	0	0	0
May	Increasing	1	0	1
	Decreasing	0	0	0
Jun	Increasing	0	0	1
	Decreasing	0	3	3
Jul	Increasing	0	0	0
	Decreasing	0	14	5
Aug	Increasing	0	0	0
	Decreasing	0	2	0
Sep	Increasing	1	0	4
	Decreasing	0	0	0
Oct	Increasing	0	0	0
	Decreasing	6	0	0
Ann	Increasing	2	1	0
	Decreasing	0	3	2

It is evident in Table 31 that the influence of V_w on increasing V_w-V_a trends has shifted focus from September to April. Ten cases in April show V_w as the causal mechanism and nine cases show both V_w and V_a playing a role in V_w-V_a trends. The influence of V_w on October decreasing trends is still present in the 40-year period; all decreasing trends in this month are attributed to behaviour in V_w. October is the only month with V_w as the causal factor of decreasing trends. Air vapour pressure still has a high influence on July decreasing trends in the 40-year period, but cases also exist where both V_w and V_a are considered the causal mechanism. The 40-year period shows a decrease in the number of trends on an annual basis in comparison to the 30-year period. This is accompanied by a reduction of cases where V_a is the causal mechanism of decreasing trends.

The 50-year period yields causal mechanisms as listed in Table 32. A decline in cases where V_a is the causal mechanism for decreasing V_w-V_a trends is illustrated in Table 32. The transition from the 40 to 50-year period caused 23 cases of V_a as the principle factor to decrease to seven. Water vapour pressure continued to have a large influence on increasing V_w-V_a trends. A monthly summary of causal mechanisms in the 50-year period is provided in Table 33.

Table 32: Causal mechanisms of 50-year V_w-V_a trends (10% level)

Causal mechanism	V_w-V_a trend	
	Increasing	Decreasing
Water vapour pressure (V_w)	27	4
Air vapour pressure (V_a)	2	5
Both	21	5
Total number of trends	50	14

Table 33: Causal mechanisms for 50-year V_w-V_a trends on a monthly basis (10% level)

Month	V_w-V_a trend	Causal Mechanism		
		V_w	V_a	both
Apr	Increasing	15	0	7
	Decreasing	0	0	0
May	Increasing	3	0	4
	Decreasing	0	0	0
Jun	Increasing	4	0	1
	Decreasing	0	0	0
Jul	Increasing	2	1	0
	Decreasing	2	3	5
Aug	Increasing	1	0	2
	Decreasing	0	1	0
Sep	Increasing	1	0	6
	Decreasing	0	0	0
Oct	Increasing	0	1	0
	Decreasing	2	0	0
Ann	Increasing	1	0	1
	Decreasing	0	1	0

In Table 33, water vapour pressure remains responsible for the majority of the increasing trends in April. Other months, such as September, show a higher influence of both V_w and V_a on increasing trends rather than just V_w alone. V_w is still the sole causal mechanism of decreasing trends in October for the 50-year period, but less cases of decreasing trends exist (in comparison with the 40-year period). Examples of V_a as a causal mechanism are dispersed and small in number. The largest number of cases affected by V_a occurs in July; however, trends existing for this month appear to be more influenced by both V_w and V_a rather than V_a alone.

Comparing Table 28, Table 30 and Table 32 shows a decline of cases where V_a is the causal mechanism as the record is lengthened; however, the influence of V_a on V_w-V_a decreasing trends is still present. The lack of cases where V_a is a causal mechanism is a result of very few decreasing trends in V_w-V_a. V_w-V_a decreasing trends were reduced with the record lengthening because increasing V_a trends demonstrated the same pattern. Therefore, V_w-V_a

decreasing trends are still displaying strong affiliations with the behaviour of V_a, even in the 50-year period.

3.3 Correlations for Pan Evaporation and Gross Evaporation

In "Analysis of Trends in Evaporation: Phase 1" (Hesch and Burn, 2005) pan and gross evaporation trends were compared. Various behaviours were noted, including matching significant trends and opposing significant trends. In order to further investigate these trends, correlations were calculated between input variables and both pan and gross evaporation. Summaries of the correlation results for pan evaporation and input variables are provided in Appendix H. High correlations to pan evaporation were found at most stations for air temperature, water vapour pressure and V_w-V_a. Negative correlations with pan evaporation were common in dew point temperature and air vapour pressure. Common ranges in correlation values for air temperature, water vapour pressure and V_w-V_a are expected as both water vapour pressure and V_w-V_a are calculated using air temperature. The resemblance of correlation values for dew point temperature and air vapour pressure also exist for a similar reason, as air vapour pressure is calculated from dew point temperature values.

Typically, of the measured values, air temperature displayed the highest correlation with pan evaporation. However, many cases demonstrated stronger correlation with V_w-V_a than air temperature alone. The highest correlation between pan evaporation and V_w-V_a, 0.943, occurs in June at Swift Current (Table H9). Norway House deviates from the typical relationship between pan evaporation and V_w-V_a (Table H7); the highest correlation is 0.560 and, in September, a negative correlation exists. The majority of the stations show weak correlations between pan evaporation and wind speed. The highest correlations do not exceed 0.6 and negative correlations are found in several cases.

Causal mechanisms in pan evaporation trends were identified based on the correlation values listed in Appendix H. Nine of the 12 significant trends found in pan evaporation illustrate V_w-V_a as the principle factor. Therefore, the behaviour of both air temperature and dew point temperature appear to be most influential on pan evaporation trends. For the remaining three pan evaporation trends, air temperature, water vapour pressure and V_w-V_a all had relatively high correlations within a close range. Because air temperature is used in the calculation of water vapour pressure and V_w-V_a, it was considered responsible for the similar behaviour of the three variables. As a result, the causal mechanism for pan evaporation trends in these cases was deemed to be air temperature. It is evident in four cases that wind speed also exerts an influence on pan evaporation. Although V_w-V_a is the main causal mechanism for all four examples, correlations for wind speed are higher than expected to occur by chance.

To assist in the identification of causal mechanisms, time-series plots were made of the evaporation measure and all input variables. Time-series plots for pan and gross evaporation can be found in Appendix I and Appendix J, respectively. An example of a time-series plot for pan evaporation at Regina in July is illustrated in Figure 1.

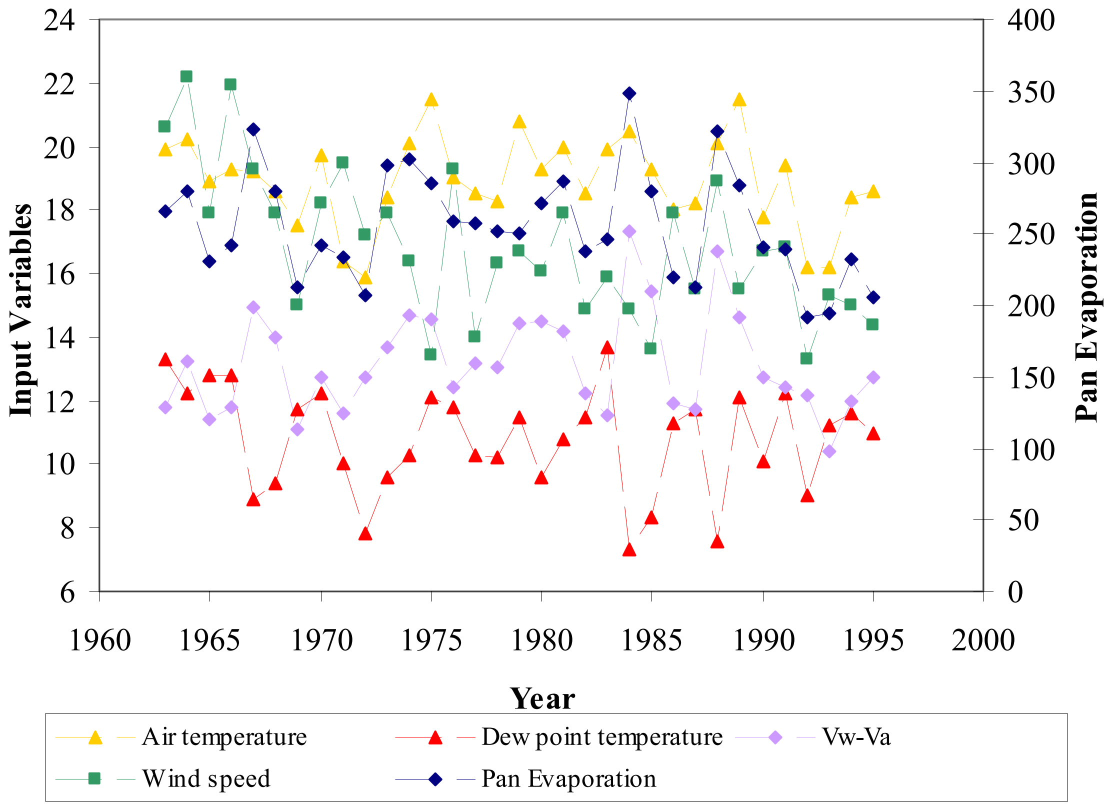

Figure 1: Time-series plot of pan evaporation and input variables at Regina in July

Figure 1 shows the relation of raw data for the input variables and pan evaporation. The inverse relation of dew point temperature and pan evaporation is evident in Figure 1. Several peaks for pan evaporation are accompanied by local minimums in dew point temperature. Behaviour that is most similar to pan evaporation in Figure 1 occurs for V_w-V_a. This is also reflected in the correlation values, as V_w-V_a has the strongest correlation to pan evaporation. The data for pan evaporation and V_w-V_a is plotted in Figure 2, as a scatter plot, to illustrate the relationship.

The scatter plot in Figure 2 shows a very close dispersion of data points, indicating a proportional increase in pan evaporation to V_w-V_a. The strong relation between the two is also reflected in the correlation of 0.850. For this particular case V_w-V_a was considered the causal mechanism in pan evaporation.

Gross evaporation correlations with each input variable are listed in Appendix K. Correlations with V_w-V_a are even stronger for gross evaporation than those seen for pan evaporation. The only cases where the correlation value between gross evaporation and V_w-V_a dropped below 0.8 occurred at Churchill (Table J3). Churchill displayed correlations between gross evaporation and V_w-V_a to be 0.741 and 0.516 for July and August, respectively. Wind speed correlations are also much higher with gross evaporation than with pan evaporation. Dew point temperature and air vapour pressure illustrate correlations that are more negative with gross evaporation than with pan evaporation. These inverse relationships with gross evaporation are expected based on input variables in Meyer's formula (Equation (1)). In comparison to gross evaporation, air temperature appears to have a higher correlation with pan evaporation in most cases at 11 of the 12 stations.

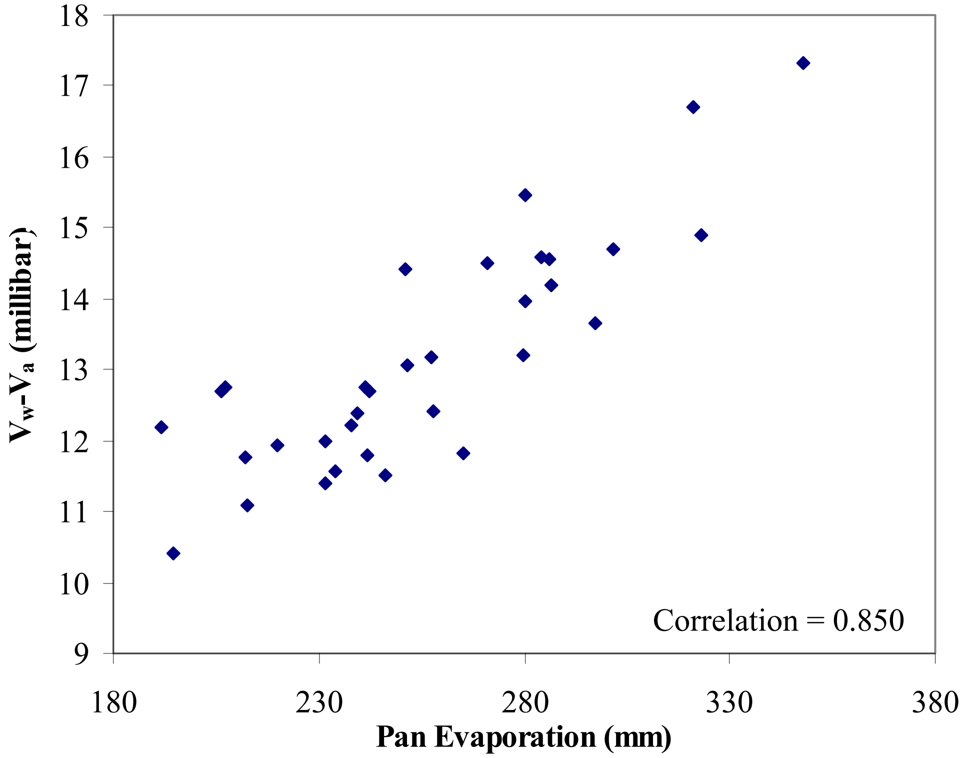

Figure 2: V_w-V_a data versus pan evaporation data in July at Regina

Correlation values for cases with matching or opposing significant trends between pan and gross evaporation (identified in "Analysis of Trends in Evaporation: Phase 1 (Hesch and Burn (2005)) were examined. In cases with matching significant trends, correlations with wind speed are within a closer range for pan and gross evaporation than cases with opposing significant trends. Three of the four cases where wind speed was considered an additional casual mechanism for pan evaporation were examples of matching significant trends between pan and gross evaporation.

To further investigate the relationship between pan and gross evaporation, causal mechanisms were identified for gross evaporation for cases with significant matching or opposing trends in pan evaporation. Although causal mechanisms were previously discussed for gross evaporation trends, this analysis utilizes time periods that coincide with those employed for pan evaporation. The process of selecting the causal mechanism for tendencies in gross evaporation was based on significant trends in input variables. For cases with matching significant trends between pan and gross evaporation, three examples exist where both wind speed and V_w-V_a are the causal mechanism. The remaining two cases indicate wind speed as the principle factor. Close to matching significant trends show four cases with wind speed as the principle factor and two cases with both V_w-V_a and wind speed as the causal mechanism. In cases where opposing significant trends exist between pan and gross evaporation, wind speed is the causal mechanism. This is also true for cases with close to opposing significant trends. These results suggest that the varying influence of wind speed is the source of discrepancies between pan and gross evaporation trends. In opposing significant trends, wind speed not only shows the same trend as gross evaporation, but there is also a strong correlation between gross evaporation and wind speed that, in some cases, is higher than the correlation with V_w-V_a. Matching significant trends that identify wind speed as the causal mechanism for gross evaporation show the same significant trend in wind speed and gross evaporation, but the correlation between gross evaporation and wind speed is much less than the correlation between gross evaporation and V_w-V_a.

The behaviour responsible for discrepancies or matching trends is summarized in Table 34. Table 34 takes into consideration the correlation values as well as significant trends that are evident in the input variables. A total of 23 cases were examined consisting of matching significant trends, opposing significant trends and significant trends for only one of the evaporation measures.

Table 34: Behaviour responsible for discrepancies or matching trends

Type	Behaviour	Number of cases for each category		
		Matching trend	Opposing trend	Trend in only one evaporation measure
1	both are affected by V_w-V_a or V_w-V_a and wind speed	5	0	1
2	wind speed is exerting an influence on gross evaporation, but not on pan evaporation	0	1	12
3	pan evaporation is influenced by air temperature	0	1	3
Total number of cases		5	2	16

Table 34 illustrates that Type 2 behaviour is the most common. Type 2 behaviour indicates that wind speed is exerting an influence on gross evaporation but not on pan evaporation. The majority of these cases are ones exhibiting decreasing trends in gross evaporation and no trend in pan evaporation. Type 1 behaviour mostly reflects cases with matching significant trends. One exception occurs and, while there is not a matching significant trend, there is a decreasing tendency for both pan and gross evaporation. The influence of air temperature on pan evaporation caused discrepancies in four cases (Type 3). All of these examples take place at separate stations in the month of May or August.

4.0 Conclusions and Recommendations

It was found in this study that most cases in October have field significant decreasing trends for the 40 and 50-year period in all variables except V_w-V_a. In the 30-year period, increasing field significant trends exist in July, August and annual trends for both dew point temperature and air vapour pressure, but cease to exist in the 50-year period. The longer record length of 50-years helps to identify increasing field significant trends for air temperature and water vapour pressure as they exist in April and June at both the 10% and 5% level. Water vapour pressure and air vapour pressure are calculated from air temperature and dew point temperature, respectively, hence the strong resemblance in their behaviours. Wind speed shows field significant decreasing trends in every example in the 30, 40 and 50-year periods. V_w-V_a field significant decreasing trends are in July for every time period and field significant increasing trends are in April for the 40 and 50-year periods. Other field significant trends for V_w-V_a do not appear for any two consecutive time periods.

July has the highest percentage of decreasing gross evaporation trends in "Analysis of Trends in Evaporation: Phase 1" (Hesch and Burn, 2005) and is the only month to show field significant decreasing trends in wind speed and V_w-V_a for all three time periods. The only field significant increasing trends in gross evaporation occur in September for the 30-year period and April for the 50-year period. Both cases show a field significant increasing trend in V_w-V_a.

Gross evaporation trends were compared to trends in input variables. All variables showed the most common result was no significant trend for either. Air temperature, water vapour pressure and wind speed illustrated multiple cases with matching trends in gross evaporation, whereas dew point temperature and air vapour pressure showed opposing trends to be more common. These relationships are to be expected based on the calculations applied to estimate the gross evaporation values.

Examining causal mechanisms for gross evaporation revealed that wind speed or V_w-V_a were typically the primary factor. The longer record lengths of 40 and 50-years indicated that wind speed generally has more of an influence in decreasing trends and V_w-V_a in increasing trends. Typically, trends in V_w-V_a are more influenced by the behaviour of V_w for increasing trends and V_a for decreasing trends.

In Phase 1 of this study (Hesch and Burn, 2005), a decreasing tendency was common in gross evaporation trends, but exceptions did occur in April and September. The behaviour in V_w-V_a is believed to be the cause of the increasing nature of gross evaporation in April. The percentage of increasing V_w-V_a trends rises substantially in April with longer record lengths, explaining the increase in percentages of increasing gross evaporation trends in April. In September, it is believed that the field significant increasing evaporation trend for the 30-year period was a result of behaviour in V_w-V_a but, as the record lengthened, wind speed became a more influential factor and caused a decreasing field significant trend in the 50-year period. It can be noted that despite the above hypothesis, the influence of V_w-V_a in September provides some inconsistencies throughout the three time periods and is not entirely understood.

In most cases, pan evaporation showed the strongest correlation with V_w-V_a and V_w-V_a was identified as the causal mechanism. Tracing the behaviour of V_w-V_a back to measured values produced examples with an influence of both air temperature and dew point temperature or solely air temperature. Of the measured values, typically the highest correlations occurred with air temperature and weak correlations existed with wind speed. Gross evaporation showed stronger correlations with wind speed in comparison to pan evaporation. Examining the discrepancies found in "Analysis of Trends in Evaporation: Phase 1" (Hesch and Burn, 2005) between pan and gross evaporation revealed that most are due to wind speed exerting an influence on gross evaporation but not pan evaporation. Several cases were also identified where pan evaporation is being influenced by air temperature resulting in a difference between pan and gross evaporation trends. Matching significant trends between pan and gross evaporation show similar causal mechanisms of V_w-V_a or both V_w-V_a and wind speed.

A more detailed examination of the influences on September gross evaporation trends is recommended due to the discrepancies identified in this study.

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Appendix A

Stations Included in Study

Table A1: Stations selected for the 30-year period

Location	Province	Latitude	Longitude	Record Length
Brandon	MB	49.92	99.95	30
Broadview	SK	50.37	102.57	30
Buffalo Narrows	SK	55.19	108.42	30
Calgary	AB	51.10	114.02	30
Churchill	MB	58.73	94.05	30
Cold Lake	AB	54.42	110.27	30
Coronation	AB	52.07	111.45	30
Dauphin	MB	51.10	100.05	30
Edmonton Intl	AB	53.32	113.57	30
Edmonton Municipal	AB	53.57	113.52	30
Edson	AB	53.57	116.47	30
Estevan	SK	49.22	102.97	30
Flin Flon	MB	54.67	101.67	30
Fort McMurry	AB	56.65	111.22	30
Fort Nelson	BC	58.83	122.60	30
Fort St. John	BC	56.23	120.73	30
Gillam	MB	56.35	94.70	30
Gimli	MB	50.62	97.02	30
Grande Prairie	AB	55.17	118.88	30
High Level	AB	58.62	117.15	30
Island Lake	MB	53.85	94.65	30
Jasper	AB	52.87	118.07	30
Kindersley	SK	51.52	109.17	30
La Ronge	SK	55.15	105.27	30
Lethbridge	AB	49.62	112.80	30
Lynn Lake	MB	56.85	101.07	30
Meadow Lake	SK	54.12	108.52	30
Medicine Hat	AB	50.02	110.72	30
Moose Jaw	SK	50.32	105.55	30
Nipawin	SK	53.32	104.00	27
North Battleford	SK	52.77	108.25	30
Norway House	MB	53.95	97.85	30
Peace River	AB	56.22	117.45	30
Pincher Creek	AB	49.50	114.00	30
Portage La Prairie	MB	49.90	98.27	30
Prince Albert	SK	53.22	105.67	30
Red Deer	AB	52.17	113.88	30
Regina	SK	50.42	104.67	30
Rocky Mtn House	AB	52.43	114.92	30
Saskatoon	SK	52.17	106.72	30
Slave Lake	AB	55.30	114.77	29
Swift Current	SK	50.30	107.67	30
The Pas	MB	53.97	101.10	30
Thompson	MB	55.80	97.87	30

Location	Province	Latitude	Longitude	Record Length
Whitecourt	AB	54.13	115.78	30
Winnipeg	MB	49.92	97.22	30
Wynyard	SK	51.77	104.20	30
Yorkton	SK	51.27	102.47	30

Table A2: Stations selected for the 40-year period

Location	Province	Latitude	Longitude	Record Length
Brandon	MB	49.92	99.95	40
Broadview	SK	50.37	102.57	40
Calgary	AB	51.10	114.02	40
Churchill	MB	58.73	94.05	40
Cold Lake	AB	54.42	110.27	40
Coronation	AB	52.07	111.45	40
Dauphin	MB	51.10	100.05	40
Edmonton Intl	AB	53.32	113.57	40
Edmonton Municipal	AB	53.57	113.52	40
Edson	AB	53.57	116.47	40
Estevan	SK	49.22	102.97	40
Fort McMurry	AB	56.65	111.22	40
Fort Nelson	BC	58.83	122.60	40
Fort St. John	BC	56.23	120.73	40
Gimli	MB	50.62	97.02	40
Grande Prairie	AB	55.17	118.88	40
Jasper	AB	52.87	118.07	39
Kindersley	SK	51.52	109.17	40
Lethbridge	AB	49.62	112.80	40
Medicine Hat	AB	50.02	110.72	40
Moose Jaw	SK	50.32	105.55	40
North Battleford	SK	52.77	108.25	40
Peace River	AB	56.22	117.45	40
Pincher Creek	AB	49.50	114.00	40
Portage La Prairie	MB	49.90	98.27	40
Prince Albert	SK	53.22	105.67	40
Red Deer	AB	52.17	113.88	40
Regina	SK	50.42	104.67	40
Rocky Mtn House	AB	52.43	114.92	40
Saskatoon	SK	52.17	106.72	40
Swift Current	SK	50.30	107.67	40
The Pas	MB	53.97	101.10	40
Whitecourt	AB	54.13	115.78	40
Winnipeg	MB	49.92	97.22	40
Wynyard	SK	51.77	104.20	36
Yorkton	SK	51.27	102.47	40

Table A3: Stations selected for the 50-year period

Location	Province	Latitude	Longitude	Record Length
Brandon	MB	49.92	99.95	50
Broadview	SK	50.37	102.57	50
Calgary	AB	51.10	114.02	50
Churchill	MB	58.73	94.05	50
Cold Lake	AB	54.42	110.27	46
Coronation	AB	52.07	111.45	48
Dauphin	MB	51.10	100.05	50
Edmonton Municipal	AB	53.57	113.52	50
Estevan	SK	49.22	102.97	50
Fort McMurray	AB	56.65	111.22	48
Fort Nelson	BC	58.83	122.60	50
Fort St. John	BC	56.23	120.73	50
Gimli	MB	50.62	97.02	50
Grande Prairie	AB	55.17	118.88	50
Lethbridge	AB	49.62	112.80	50
Medicine Hat	AB	50.02	110.72	50
Moose Jaw	SK	50.32	105.55	48
North Battleford	SK	52.77	108.25	50
Peace River	AB	56.22	117.45	50
Portage La Prairie	MB	49.90	98.27	48
Prince Albert	SK	53.22	105.67	50
Red Deer	AB	52.17	113.88	50
Regina	SK	50.42	104.67	50
Rocky Mtn House	AB	52.43	114.92	50
Saskatoon	SK	52.17	106.72	50
Swift Current	SK	50.30	107.67	50
The Pas	MB	53.97	101.10	50
Whitecourt	AB	54.13	115.78	50
Winnipeg	MB	49.92	97.22	50
Yorkton	SK	51.27	102.47	48

Appendix B

Stations Selected for Comparing Pan and Gross Evaporation Trends

Table B1: Stations selected for comparing pan and gross evaporation trends

Pan Evaporation Station	Gross Evaporation Station	Province	Month	Period of Record
Altawan	Medicine Hat	AB	June	1966-1996
Altawan	Medicine Hat	AB	July	1966-1996
Altawan	Medicine Hat	AB	Aug	1966-1996
Altawan	Medicine Hat	AB	Sept	1966-1996
Calgary Intl A	Calgary	AB	June	1965-1994
Calgary Intl A	Calgary	AB	July	1964-1994
Calgary Intl A	Calgary	AB	Aug	1964-1994
Calgary Intl A	Calgary	AB	Sept	1964-1994
Churchill A	Churchill	MB	July	1964-2000
Churchill A	Churchill	MB	Aug	1964-2000
Estevan A	Estevan	SK	May	1962-2000
Estevan A	Estevan	SK	June	1962-2000
Estevan A	Estevan	SK	July	1962-2000
Estevan A	Estevan	SK	Aug	1962-2000
Estevan A	Estevan	SK	Sept	1962-2000
Morden CDA	Portage La Prairie	MB	May	1963-1998
Morden CDA	Portage La Prairie	MB	June	1963-1998
Morden CDA	Portage La Prairie	MB	July	1963-1998
Morden CDA	Portage La Prairie	MB	Aug	1963-1998
Nipawin A	Nipawin	SK	May	1974-2000
Nipawin A	Nipawin	SK	June	1974-2000
Nipawin A	Nipawin	SK	July	1974-2000
Nipawin A	Nipawin	SK	Aug	1974-2000
Nipawin A	Nipawin	SK	Sept	1974-2000
Norway House Forestry	Norway House	MB	June	1972-2000
Norway House Forestry	Norway House	MB	July	1971-2000
Norway House Forestry	Norway House	MB	Aug	1971-1999
Norway House Forestry	Norway House	MB	Sept	1971-1999
Regina A	Regina	SK	May	1963-1995
Regina A	Regina	SK	June	1963-1995
Regina A	Regina	SK	July	1963-1995
Regina A	Regina	SK	Aug	1963-1994
Regina A	Regina	SK	Sept	1962-1994
Swift Current CDA	Swift Current	SK	May	1961-2000
Swift Current CDA	Swift Current	SK	June	1960-1999
Swift Current CDA	Swift Current	SK	July	1960-1999
Swift Current CDA	Swift Current	SK	Aug	1960-2000
Swift Current CDA	Swift Current	SK	Sept	1960-2000
Weyburn	Regina	SK	May	1962-2000
Weyburn	Regina	SK	June	1962-2000
Weyburn	Regina	SK	July	1962-2000

Pan Evaporation Station	Gross Evaporation Station	Province	Month	Period of Record
Weyburn	Regina	SK	Aug	1962-2000
Weyburn	Regina	SK	Sept	1962-2000
Winnipeg Intl A	Winnipeg	MB	May	1963-1994
Winnipeg Intl A	Winnipeg	MB	June	1962-1996
Winnipeg Intl A	Winnipeg	MB	July	1962-1996
Winnipeg Intl A	Winnipeg	MB	Aug	1962-1994
Winnipeg Intl A	Winnipeg	MB	Sept	1962-1994
Wynyard	Wynyard	SK	May	1967-2000
Wynyard	Wynyard	SK	June	1967-2000
Wynyard	Wynyard	SK	July	1967-1999
Wynyard	Wynyard	SK	Aug	1967-1999
Wynyard	Wynyard	SK	Sept	1967-2000

Appendix C

Location Summary of Significant Trends at the 10% Level

Table C1: Location summary of 30-year air temperature trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	0	0	8
Buffalo Narrows	0	0	8
Calgary	0	0	8
Churchill	3	0	4
Cold Lake	0	0	8
Coronation	0	1	7
Dauphin	0	0	8
Edmonton Intl	2	0	6
Edmonton Mun	0	0	8
Edson	1	0	7
Estevan	0	1	7
Flin Flon	1	0	7
Fort McMurray	0	0	8
Fort Nelson	0	1	7
Fort St John	0	0	8
Gillam	5	0	2
Gimli	0	0	8
Grande Prairie	0	0	8
High Level	0	0	8
Island Lake	0	0	8
Jasper	0	0	8
Kindersley	0	1	7
La Ronge	0	0	8
Lethbridge	0	0	8
Lynn Lake	1	1	5
Meadow Lake	0	1	7
Medicine Hat	0	0	8
Moose Jaw	0	1	7
Nipawin	1	0	7
North Battleford	0	1	7
Norway House	0	0	8
Peace River	0	0	8
Pincher Creek	0	0	8
Portage La Prairie	0	0	8
Prince Albert	2	0	6
Red Deer	0	0	8
Regina	0	0	8

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	0	1	7
Saskatoon	0	0	8
Slave Lake	3	0	5
Swift Current	0	0	8
The Pas	0	0	8
Thompson	3	0	4
Whitecourt	0	0	8
Winnipeg	0	0	8
Wynyard	0	0	8
Yorkton	0	0	8

Table C2: Location summary of 40-year air temperature trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	1	7
Broadview	2	0	6
Calgary	1	0	7
Churchill	3	0	4
Cold Lake	1	1	6
Coronation	0	2	6
Dauphin	0	0	8
Edmonton Intl	2	0	6
Edmonton Mun	1	1	6
Edson	0	1	7
Estevan	0	1	7
Fort McMurray	0	0	8
Fort Nelson	2	1	5
Fort St John	1	0	7
Gimli	0	1	7
Grande Prairie	1	1	6
Jasper	0	1	7
Kindersley	0	1	7
Lethbridge	0	1	7
Medicine Hat	0	1	7
Moose Jaw	0	1	7
North Battleford	1	1	6
Peace River	3	1	4
Pincher Creek	0	1	7
Portage La Prairie	0	1	7
Prince Albert	2	0	6
Red Deer	0	1	7
Regina	0	1	7
Rocky Mtn House	0	2	6
Saskatoon	0	0	8
Swift Current	0	1	7
The Pas	0	0	8
Whitecourt	3	0	5
Winnipeg	0	1	7
Wynyard	0	0	8
Yorkton	0	1	7

Table C3: Location summary of 50-year air temperature trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	1	7
Broadview	4	0	4
Calgary	2	0	6
Churchill	0	0	7
Cold Lake	1	0	7
Coronation	1	2	5
Dauphin	0	1	7
Edmonton Mun	3	0	5
Estevan	0	1	7
Fort McMurray	3	0	5
Fort Nelson	3	0	5
Fort St John	1	0	7
Gimli	0	1	7
Grande Prairie	3	0	5
Lethbridge	1	0	7
Medicine Hat	1	0	7
Moose Jaw	1	1	6
North Battleford	1	1	6
Peace River	3	0	5
Portage La Prairie	0	1	7
Prince Albert	3	0	5
Red Deer	1	0	7
Regina	2	0	6
Rocky Mtn House	0	1	7
Saskatoon	1	0	7
Swift Current	1	1	6
The Pas	0	0	8
Whitecourt	5	0	3
Winnipeg	0	1	7
Yorkton	0	1	7

Table C4: Location summary of 30-year dew point temperature trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	3	0	5
Broadview	2	0	6
Buffalo Narrows	0	0	8
Calgary	3	0	5
Churchill	5	0	2
Cold Lake	0	0	8
Coronation	1	0	7
Dauphin	4	0	4
Edmonton Intl	0	0	8
Edmonton Mun	3	0	5
Edson	0	0	8
Estevan	1	0	7
Flin Flon	1	0	7
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gillam	3	0	4
Gimli	3	0	5
Grande Prairie	0	0	8
High Level	0	0	8
Island Lake	2	0	6
Jasper	1	0	7
Kindersley	1	0	7
La Ronge	0	0	8
Lethbridge	1	0	7
Lynn Lake	1	0	6
Meadow Lake	0	0	8
Medicine Hat	1	0	7
Moose Jaw	5	0	3
Nipawin	1	1	6
North Battleford	3	0	5
Norway House	3	0	5
Peace River	0	1	7
Pincher Creek	2	0	6
Portage La Prairie	3	0	5
Prince Albert	0	0	8
Red Deer	1	0	7
Regina	4	0	4

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	1	0	7
Saskatoon	4	0	4
Slave Lake	1	0	7
Swift Current	4	0	4
The Pas	2	0	6
Thompson	3	0	4
Whitecourt	0	0	8
Winnipeg	5	0	3
Wynyard	1	0	7
Yorkton	3	0	5

Table C5: Location summary of 40-year dew point temperature trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	2	1	5
Calgary	1	1	6
Churchill	3	0	4
Cold Lake	0	0	8
Coronation	1	1	6
Dauphin	4	1	3
Edmonton Intl	0	1	7
Edmonton Mun	3	0	5
Edson	0	1	7
Estevan	0	0	8
Fort McMurray	0	1	7
Fort Nelson	1	0	7
Fort St John	0	0	8
Gimli	5	0	3
Grande Prairie	0	0	8
Jasper	0	0	8
Kindersley	0	0	8
Lethbridge	0	1	7
Medicine Hat	0	0	8
Moose Jaw	2	0	6
North Battleford	0	1	7
Peace River	0	1	7
Pincher Creek	0	0	8
Portage La Prairie	2	0	6
Prince Albert	0	1	7
Red Deer	0	0	8
Regina	0	0	8
Rocky Mtn House	0	1	7
Saskatoon	4	0	4
Swift Current	1	0	7
The Pas	0	1	7
Whitecourt	4	0	4
Winnipeg	4	0	4
Wynyard	1	0	7
Yorkton	1	0	7

Table C6: Location summary of 50-year dew point temperature trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	1	7
Broadview	0	0	8
Calgary	0	1	7
Churchill	0	0	7
Cold Lake	0	0	8
Coronation	0	1	7
Dauphin	0	1	7
Edmonton Mun	0	0	8
Estevan	0	0	8
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gimli	4	1	3
Grande Prairie	0	0	8
Lethbridge	0	1	7
Medicine Hat	0	0	8
Moose Jaw	0	0	8
North Battleford	0	1	7
Peace River	0	1	7
Portage La Prairie	1	1	6
Prince Albert	0	1	7
Red Deer	0	2	6
Regina	0	0	8
Rocky Mtn House	0	1	7
Saskatoon	1	0	7
Swift Current	0	0	8
The Pas	0	2	6
Whitecourt	4	0	4
Winnipeg	2	0	6
Yorkton	0	1	7

Table C7: Location summary of 30-year air vapour pressure trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	3	0	5
Broadview	3	0	5
Buffalo Narrows	0	0	8
Calgary	3	0	5
Churchill	5	0	2
Cold Lake	0	0	8
Coronation	1	0	7
Dauphin	4	0	4
Edmonton Intl	0	0	8
Edmonton Mun	3	0	5
Edson	0	0	8
Estevan	1	0	7
Flin Flon	1	0	7
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gillam	4	0	3
Gimli	3	0	5
Grande Prairie	0	0	8
High Level	0	0	8
Island Lake	3	0	5
Jasper	1	0	7
Kindersley	1	0	7
La Ronge	0	0	8
Lethbridge	1	0	7
Lynn Lake	2	0	5
Meadow Lake	0	0	8
Medicine Hat	1	0	7
Moose Jaw	5	0	3
Nipawin	1	1	6
North Battleford	3	0	5
Norway House	4	0	4
Peace River	0	1	7
Pincher Creek	2	0	6
Portage La Prairie	3	0	5
Prince Albert	0	0	8
Red Deer	1	0	7
Regina	5	0	3

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	2	0	6
Saskatoon	4	0	4
Slave Lake	1	0	7
Swift Current	5	0	3
The Pas	2	0	6
Thompson	4	0	3
Whitecourt	0	0	8
Winnipeg	5	0	3
Wynyard	1	0	7
Yorkton	3	0	5

Table C8: Location summary of 40-year air vapour pressure trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	2	1	5
Calgary	2	1	5
Churchill	3	0	4
Cold Lake	0	0	8
Coronation	2	1	5
Dauphin	4	1	3
Edmonton Intl	0	1	7
Edmonton Mun	3	0	5
Edson	0	1	7
Estevan	0	1	7
Fort McMurray	0	1	7
Fort Nelson	1	0	7
Fort St John	0	0	8
Gimli	5	0	3
Grande Prairie	0	0	8
Jasper	0	0	8
Kindersley	1	0	7
Lethbridge	0	1	7
Medicine Hat	0	0	8
Moose Jaw	2	0	6
North Battleford	1	1	6
Peace River	0	1	7
Pincher Creek	0	0	8
Portage La Prairie	3	0	5
Prince Albert	0	1	7
Red Deer	0	0	8
Regina	1	0	7
Rocky Mtn House	0	1	7
Saskatoon	4	0	4
Swift Current	1	0	7
The Pas	0	1	7
Whitecourt	4	0	4
Winnipeg	4	0	4
Wynyard	1	0	7
Yorkton	1	0	7

Table C9: Location summary of 50-year air vapour pressure trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	1	0	7
Calgary	0	1	7
Churchill	0	0	7
Cold Lake	1	0	7
Coronation	0	1	7
Dauphin	0	1	7
Edmonton Mun	0	0	8
Estevan	0	0	8
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gimli	4	1	3
Grande Prairie	0	0	8
Lethbridge	0	1	7
Medicine Hat	0	0	8
Moose Jaw	0	0	8
North Battleford	0	1	7
Peace River	0	1	7
Portage La Prairie	1	1	6
Prince Albert	0	1	7
Red Deer	0	2	6
Regina	0	0	8
Rocky Mtn House	0	1	7
Saskatoon	1	0	7
Swift Current	0	0	8
The Pas	0	1	7
Whitecourt	4	0	4
Winnipeg	3	0	5
Yorkton	0	1	7

Table C10: Location summary of 30-year water vapour pressure trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	1	0	7
Buffalo Narrows	0	0	6
Calgary	0	0	8
Churchill	3	0	1
Cold Lake	0	0	8
Coronation	0	1	7
Dauphin	0	0	8
Edmonton Intl	2	0	6
Edmonton Mun	0	0	8
Edson	1	0	7
Estevan	0	1	7
Flin Flon	0	0	6
Fort McMurray	0	0	6
Fort Nelson	0	0	5
Fort St John	0	0	8
Gillam	4	0	1
Gimli	0	0	8
Grande Prairie	0	0	8
High Level	0	0	5
Island Lake	0	0	6
Jasper	0	0	8
Kindersley	0	0	8
La Ronge	0	0	6
Lethbridge	0	0	8
Lynn Lake	1	0	4
Meadow Lake	0	1	7
Medicine Hat	0	0	8
Moose Jaw	0	0	8
Nipawin	1	0	7
North Battleford	0	1	7
Norway House	0	0	6
Peace River	0	0	8
Pincher Creek	0	0	8
Portage La Prairie	0	0	8
Prince Albert	2	0	6
Red Deer	0	0	8
Regina	0	0	8

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	0	2	6
Saskatoon	0	0	8
Slave Lake	3	0	5
Swift Current	0	0	8
The Pas	0	0	6
Thompson	3	0	2
Whitecourt	0	0	8
Winnipeg	0	0	8
Wynyard	0	0	8
Yorkton	0	0	8

Table C11: Location summary of 40-year water vapour pressure trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	1	7
Broadview	2	0	6
Calgary	1	0	7
Churchill	2	0	2
Cold Lake	1	1	6
Coronation	0	2	6
Dauphin	1	1	6
Edmonton Intl	1	0	7
Edmonton Mun	1	1	6
Edson	0	1	7
Estevan	0	1	7
Fort McMurray	0	0	6
Fort Nelson	1	0	4
Fort St John	1	0	7
Gimli	0	1	7
Grande Prairie	1	1	6
Jasper	0	1	7
Kindersley	0	1	7
Lethbridge	0	1	7
Medicine Hat	0	1	7
Moose Jaw	0	1	7
North Battleford	1	1	6
Peace River	3	1	4
Pincher Creek	0	1	7
Portage La Prairie	0	1	7
Prince Albert	2	0	6
Red Deer	1	1	6
Regina	0	1	7
Rocky Mtn House	0	2	6
Saskatoon	0	0	8
Swift Current	0	1	7
The Pas	0	1	5
Whitecourt	3	0	5
Winnipeg	0	0	8
Wynyard	0	0	8
Yorkton	0	1	7

Table C12: Location summary of 50-year water vapour pressure trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	1	7
Broadview	5	0	3
Calgary	1	0	7
Churchill	0	0	4
Cold Lake	1	0	7
Coronation	1	2	5
Dauphin	1	1	6
Edmonton Mun	3	0	5
Estevan	0	1	7
Fort McMurray	2	0	4
Fort Nelson	1	0	4
Fort St John	1	0	7
Gimli	0	1	7
Grande Prairie	2	0	6
Lethbridge	1	0	7
Medicine Hat	1	0	7
Moose Jaw	1	1	6
North Battleford	0	1	7
Peace River	3	0	5
Portage La Prairie	0	1	7
Prince Albert	3	0	5
Red Deer	1	0	7
Regina	2	0	6
Rocky Mtn House	0	2	6
Saskatoon	1	0	7
Swift Current	1	1	6
The Pas	0	0	6
Whitecourt	5	0	3
Winnipeg	0	1	7
Yorkton	0	1	7

Table C13: Location summary of 30-year V_w-V_a trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	3	5
Broadview	0	3	5
Buffalo Narrows	0	0	6
Calgary	0	3	5
Churchill	0	1	3
Cold Lake	0	1	7
Coronation	0	4	4
Dauphin	0	3	5
Edmonton Intl	1	0	7
Edmonton Mun	0	3	5
Edson	3	0	5
Estevan	0	2	6
Flin Flon	0	0	6
Fort McMurray	0	0	6
Fort Nelson	0	0	5
Fort St John	0	1	7
Gillam	1	0	4
Gimli	0	4	4
Grande Prairie	2	0	6
High Level	1	0	4
Island Lake	0	0	6
Jasper	0	1	7
Kindersley	0	0	8
La Ronge	2	0	4
Lethbridge	0	2	6
Lynn Lake	0	0	5
Meadow Lake	0	0	8
Medicine Hat	0	0	8
Moose Jaw	0	3	5
Nipawin	3	0	5
North Battleford	0	2	6
Norway House	0	1	5
Peace River	3	0	5
Pincher Creek	0	1	7
Portage La Prairie	0	2	6
Prince Albert	1	0	7
Red Deer	0	0	8
Regina	0	4	4

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	0	4	4
Saskatoon	0	3	5
Slave Lake	2	0	6
Swift Current	0	4	4
The Pas	0	0	6
Thompson	0	0	5
Whitecourt	1	0	7
Winnipeg	0	4	4
Wynyard	0	3	5
Yorkton	0	4	4

Table C14: Location summary of 40-year V_w-V_a trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	1	1	6
Broadview	1	1	6
Calgary	1	1	6
Churchill	0	0	4
Cold Lake	1	0	7
Coronation	0	3	5
Dauphin	1	2	5
Edmonton Intl	1	0	7
Edmonton Mun	0	3	5
Edson	2	0	6
Estevan	0	1	7
Fort McMurray	1	0	5
Fort Nelson	0	1	4
Fort St John	1	2	5
Gimli	0	4	4
Grande Prairie	2	0	6
Jasper	1	1	6
Kindersley	1	0	7
Lethbridge	1	1	6
Medicine Hat	1	0	7
Moose Jaw	0	1	7
North Battleford	1	1	6
Peace River	4	0	4
Pincher Creek	0	1	7
Portage La Prairie	1	2	5
Prince Albert	5	0	3
Red Deer	0	3	5
Regina	0	1	7
Rocky Mtn House	0	1	7
Saskatoon	0	1	7
Swift Current	0	2	6
The Pas	0	0	6
Whitecourt	0	0	8
Winnipeg	1	1	6
Wynyard	1	2	5
Yorkton	1	1	6

Table C15: Location summary of 50-year V_w-V_a trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	1	1	6
Broadview	2	0	6
Calgary	2	0	6
Churchill	3	0	1
Cold Lake	1	0	7
Coronation	1	1	6
Dauphin	3	0	5
Edmonton Mun	2	0	6
Estevan	0	0	8
Fort McMurray	5	0	1
Fort Nelson	1	0	4
Fort St John	1	0	7
Gimli	0	3	5
Grande Prairie	2	0	6
Lethbridge	1	0	7
Medicine Hat	1	0	7
Moose Jaw	0	2	6
North Battleford	2	1	5
Peace River	2	0	6
Portage La Prairie	1	1	6
Prince Albert	5	0	3
Red Deer	1	0	7
Regina	3	0	5
Rocky Mtn House	1	1	6
Saskatoon	1	1	6
Swift Current	1	1	6
The Pas	5	0	1
Whitecourt	0	0	8
Winnipeg	1	1	6
Yorkton	1	1	6

Table C16: Location summary of 30-year wind speed trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	4	4
Broadview	7	0	1
Buffalo Narrows	8	0	0
Calgary	0	0	8
Churchill	1	0	6
Cold Lake	0	1	7
Coronation	0	7	1
Dauphin	0	7	1
Edmonton Intl	0	1	7
Edmonton Mun	1	0	7
Edson	0	0	8
Estevan	0	6	2
Flin Flon	0	1	7
Fort McMurray	0	3	5
Fort Nelson	4	0	4
Fort St John	0	5	3
Gillam	0	2	5
Gimli	4	0	4
Grande Prairie	0	2	6
High Level	6	0	2
Island Lake	0	1	7
Jasper	0	8	0
Kindersley	5	0	3
La Ronge	5	0	3
Lethbridge	0	1	7
Lynn Lake	0	7	0
Meadow Lake	8	0	0
Medicine Hat	0	8	0
Moose Jaw	0	2	6
Nipawin	4	0	4
North Battleford	0	4	4
Norway House	0	8	0
Peace River	0	1	7
Pincher Creek	1	1	6
Portage La Prairie	0	6	2
Prince Albert	0	6	2
Red Deer	0	8	0
Regina	0	1	7

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	0	6	2
Saskatoon	0	7	1
Slave Lake	0	2	6
Swift Current	0	1	7
The Pas	0	1	7
Thompson	0	1	6
Whitecourt	0	0	8
Winnipeg	0	0	8
Wynyard	0	8	0
Yorkton	0	4	4

Table C17: Location summary of 40-year wind speed trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	2	6
Broadview	0	0	8
Calgary	0	0	8
Churchill	0	0	7
Cold Lake	0	8	0
Coronation	0	0	8
Dauphin	0	8	0
Edmonton Intl	0	8	0
Edmonton Mun	0	0	8
Edson	0	4	4
Estevan	0	6	2
Fort McMurray	0	3	5
Fort Nelson	0	2	6
Fort St John	0	8	0
Gimli	0	3	5
Grande Prairie	0	6	2
Jasper	0	8	0
Kindersley	0	0	8
Lethbridge	0	2	6
Medicine Hat	0	7	1
Moose Jaw	0	8	0
North Battleford	0	4	4
Peace River	0	0	8
Pincher Creek	0	0	8
Portage La Prairie	0	8	0
Prince Albert	0	8	0
Red Deer	0	8	0
Regina	0	7	1
Rocky Mtn House	0	6	2
Saskatoon	0	2	6
Swift Current	0	8	0
The Pas	0	8	0
Whitecourt	0	0	8
Winnipeg	0	3	5
Wynyard	0	8	0
Yorkton	0	8	0

Table C18: Location summary of 50-year wind speed trends (10% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	5	3
Broadview	0	1	7
Calgary	0	0	8
Churchill	0	1	6
Cold Lake	0	8	0
Coronation	0	0	8
Dauphin	0	6	2
Edmonton Mun	0	1	7
Estevan	0	5	3
Fort McMurray	0	2	6
Fort Nelson	0	5	3
Fort St John	0	8	0
Gimli	0	4	4
Grande Prairie	0	8	0
Lethbridge	0	2	6
Medicine Hat	0	4	4
Moose Jaw	0	8	0
North Battleford	0	7	1
Peace River	8	0	0
Portage La Prairie	0	8	0
Prince Albert	0	8	0
Red Deer	0	8	0
Regina	0	2	6
Rocky Mtn House	0	7	1
Saskatoon	0	0	8
Swift Current	0	8	0
The Pas	0	8	0
Whitecourt	0	6	2
Winnipeg	0	5	3
Yorkton	0	8	0

Appendix D

Location Summary of Significant Trends at the 5% Level

Table D1: Location summary of 30-year air temperature trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	0	0	8
Buffalo Narrows	0	0	8
Calgary	0	0	8
Churchill	2	0	5
Cold Lake	0	0	8
Coronation	0	0	8
Dauphin	0	0	8
Edmonton Intl	0	0	8
Edmonton Mun	0	0	8
Edson	0	0	8
Estevan	0	1	7
Flin Flon	0	0	8
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gillam	1	0	6
Gimli	0	0	8
Grande Prairie	0	0	8
High Level	0	0	8
Island Lake	0	0	8
Jasper	0	0	8
Kindersley	0	0	8
La Ronge	0	0	8
Lethbridge	0	0	8
Lynn Lake	0	0	7
Meadow Lake	0	1	7
Medicine Hat	0	0	8
Moose Jaw	0	0	8
Nipawin	1	0	7
North Battleford	0	0	8
Norway House	0	0	8
Peace River	0	0	8
Pincher Creek	0	0	8
Portage La Prairie	0	0	8
Prince Albert	0	0	8
Red Deer	0	0	8
Regina	0	0	8

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	0	1	7
Saskatoon	0	0	8
Slave Lake	1	0	7
Swift Current	0	0	8
The Pas	0	0	8
Thompson	1	0	6
Whitecourt	0	0	8
Winnipeg	0	0	8
Wynyard	0	0	8
Yorkton	0	0	8

Table D2: Location summary of 40-year air temperature trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	1	7
Broadview	1	0	7
Calgary	0	0	8
Churchill	0	0	7
Cold Lake	0	0	8
Coronation	0	1	7
Dauphin	0	0	8
Edmonton Intl	1	0	7
Edmonton Mun	1	0	7
Edson	0	1	7
Estevan	0	1	7
Fort McMurray	0	0	8
Fort Nelson	1	1	6
Fort St John	1	0	7
Gimli	0	1	7
Grande Prairie	1	1	6
Jasper	0	1	7
Kindersley	0	0	8
Lethbridge	0	1	7
Medicine Hat	0	0	8
Moose Jaw	0	1	7
North Battleford	0	1	7
Peace River	1	0	7
Pincher Creek	0	1	7
Portage La Prairie	0	1	7
Prince Albert	0	0	8
Red Deer	0	1	7
Regina	0	1	7
Rocky Mtn House	0	2	6
Saskatoon	0	0	8
Swift Current	0	1	7
The Pas	0	0	8
Whitecourt	2	0	6
Winnipeg	0	0	8
Wynyard	0	0	8
Yorkton	0	1	7

Table D3: Location summary of 50-year air temperature trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	1	7
Broadview	2	0	6
Calgary	1	0	7
Churchill	0	0	7
Cold Lake	0	0	8
Coronation	1	1	6
Dauphin	0	0	8
Edmonton Mun	2	0	6
Estevan	0	1	7
Fort McMurray	3	0	5
Fort Nelson	2	0	6
Fort St John	1	0	7
Gimli	0	1	7
Grande Prairie	3	0	5
Lethbridge	1	0	7
Medicine Hat	1	0	7
Moose Jaw	0	1	7
North Battleford	0	0	8
Peace River	3	0	5
Portage La Prairie	0	1	7
Prince Albert	3	0	5
Red Deer	1	0	7
Regina	0	0	8
Rocky Mtn House	0	1	7
Saskatoon	0	0	8
Swift Current	1	0	7
The Pas	0	0	8
Whitecourt	3	0	5
Winnipeg	0	0	8
Yorkton	0	1	7

Table D4: Location summary of 30-year dew point temperature trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	2	0	6
Broadview	2	0	6
Buffalo Narrows	0	0	6
Calgary	2	0	6
Churchill	5	0	2
Cold Lake	0	0	8
Coronation	1	0	7
Dauphin	3	0	5
Edmonton Intl	0	0	8
Edmonton Mun	1	0	7
Edson	0	0	8
Estevan	1	0	7
Flin Flon	0	0	8
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gillam	1	0	7
Gimli	2	0	6
Grande Prairie	0	0	8
High Level	0	0	8
Island Lake	2	0	6
Jasper	0	0	8
Kindersley	0	0	8
La Ronge	0	0	8
Lethbridge	0	0	8
Lynn Lake	0	0	7
Meadow Lake	0	0	8
Medicine Hat	0	0	8
Moose Jaw	3	0	5
Nipawin	0	1	7
North Battleford	1	0	7
Norway House	1	0	7
Peace River	0	0	8
Pincher Creek	0	0	8
Portage La Prairie	1	0	7
Prince Albert	0	0	8
Red Deer	0	0	8
Regina	2	0	6

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	1	0	7
Saskatoon	3	0	5
Slave Lake	0	0	8
Swift Current	2	0	6
The Pas	0	0	8
Thompson	3	0	4
Whitecourt	0	0	8
Winnipeg	4	0	4
Wynyard	0	0	8
Yorkton	2	0	6

Table D5: Location summary of 40-year dew point temperature trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	1	0	7
Calgary	0	0	8
Churchill	0	0	7
Cold Lake	0	0	8
Coronation	0	0	8
Dauphin	3	0	8
Edmonton Intl	0	0	8
Edmonton Mun	0	0	8
Edson	0	1	7
Estevan	0	0	8
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gimli	4	0	4
Grande Prairie	0	0	8
Jasper	0	0	8
Kindersley	0	0	8
Lethbridge	0	1	7
Medicine Hat	0	0	8
Moose Jaw	2	0	6
North Battleford	0	0	8
Peace River	0	1	7
Pincher Creek	0	0	8
Portage La Prairie	2	0	6
Prince Albert	0	1	7
Red Deer	0	0	8
Regina	0	0	8
Rocky Mtn House	0	1	7
Saskatoon	1	0	7
Swift Current	1	0	7
The Pas	0	0	8
Whitecourt	4	0	4
Winnipeg	3	0	5
Wynyard	0	0	8
Yorkton	0	0	8

Table D6: Location summary of 50-year dew point temperature trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	0	0	8
Calgary	0	0	8
Churchill	0	0	7
Cold Lake	0	0	8
Coronation	0	0	8
Dauphin	0	1	7
Edmonton Mun	0	0	8
Estevan	0	0	8
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gimli	1	0	7
Grande Prairie	0	0	8
Lethbridge	0	0	8
Medicine Hat	0	0	8
Moose Jaw	0	0	8
North Battleford	0	0	8
Peace River	0	1	7
Portage La Prairie	0	0	8
Prince Albert	0	1	7
Red Deer	0	0	8
Regina	0	0	8
Rocky Mtn House	0	0	8
Saskatoon	0	0	8
Swift Current	0	0	8
The Pas	0	1	7
Whitecourt	4	0	4
Winnipeg	0	0	8
Yorkton	0	0	8

Table D7: Location summary of 30-year air vapour pressure trends (5% level)

Location	Trends		
	Increasing	Decreasing	No trend
Brandon	3	0	5
Broadview	3	0	5
Buffalo Narrows	0	0	8
Calgary	3	0	5
Churchill	5	0	2
Cold Lake	0	0	8
Coronation	1	0	7
Dauphin	3	0	5
Edmonton Intl	0	0	8
Edmonton Mun	1	0	7
Edson	0	0	8
Estevan	1	0	7
Flin Flon	0	0	8
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gillam	2	0	5
Gimli	2	0	6
Grande Prairie	0	0	8
High Level	0	0	8
Island Lake	3	0	5
Jasper	1	0	7
Kindersley	0	0	8
La Ronge	0	0	8
Lethbridge	0	0	8
Lynn Lake	0	0	7
Meadow Lake	0	0	8
Medicine Hat	0	0	8
Moose Jaw	2	0	6
Nipawin	0	1	7
North Battleford	2	0	6
Norway House	2	0	6
Peace River	0	1	7
Pincher Creek	0	0	8
Portage La Prairie	2	0	6
Prince Albert	0	0	8
Red Deer	0	0	8
Regina	2	0	6

Location	Trends		
	Increasing	Decreasing	No trend
Rocky Mtn House	2	0	6
Saskatoon	3	0	5
Slave Lake	0	0	8
Swift Current	3	0	5
The Pas	0	0	8
Thompson	4	0	3
Whitecourt	0	0	8
Winnipeg	4	0	4
Wynyard	1	0	7
Yorkton	3	0	5

Table D8: Location summary of 40-year air vapour pressure trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	1	0	7
Calgary	0	0	8
Churchill	1	0	6
Cold Lake	0	0	8
Coronation	0	0	8
Dauphin	3	0	5
Edmonton Intl	0	0	8
Edmonton Mun	1	0	7
Edson	0	1	7
Estevan	0	0	8
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gimli	4	0	4
Grande Prairie	0	0	8
Jasper	0	0	8
Kindersley	0	0	8
Lethbridge	0	1	7
Medicine Hat	0	0	8
Moose Jaw	2	0	6
North Battleford	1	0	7
Peace River	0	1	7
Pincher Creek	0	0	8
Portage La Prairie	2	0	6
Prince Albert	0	1	7
Red Deer	0	0	8
Regina	0	0	8
Rocky Mtn House	0	1	7
Saskatoon	1	0	7
Swift Current	1	0	7
The Pas	0	0	8
Whitecourt	4	0	4
Winnipeg	4	0	4
Wynyard	0	0	8
Yorkton	0	0	8

Table D9: Location summary of 50-year air vapour pressure trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	0	0	8
Calgary	0	1	7
Churchill	0	0	7
Cold Lake	0	0	8
Coronation	0	0	8
Dauphin	0	1	7
Edmonton Mun	0	0	8
Estevan	0	0	8
Fort McMurray	0	0	8
Fort Nelson	0	0	8
Fort St John	0	0	8
Gimli	2	0	6
Grande Prairie	0	0	8
Lethbridge	0	0	8
Medicine Hat	0	0	8
Moose Jaw	0	0	8
North Battleford	0	0	8
Peace River	0	1	7
Portage La Prairie	0	0	8
Prince Albert	0	1	7
Red Deer	0	0	8
Regina	0	0	8
Rocky Mtn House	0	0	8
Saskatoon	0	0	8
Swift Current	0	0	8
The Pas	0	1	7
Whitecourt	4	0	4
Winnipeg	0	0	8
Yorkton	0	0	8

Table D10: Location summary of 30-year water vapour pressure trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	0	8
Broadview	0	0	8
Buffalo Narrows	0	0	6
Calgary	0	0	8
Churchill	2	0	2
Cold Lake	0	0	8
Coronation	0	0	8
Dauphin	0	0	8
Edmonton Intl	0	0	8
Edmonton Mun	0	0	8
Edson	0	0	8
Estevan	0	1	7
Flin Flon	0	0	6
Fort McMurray	0	0	6
Fort Nelson	0	0	5
Fort St John	0	0	8
Gillam	1	0	4
Gimli	0	0	8
Grande Prairie	0	0	8
High Level	0	0	5
Island Lake	0	0	6
Jasper	0	0	8
Kindersley	0	0	8
La Ronge	0	0	6
Lethbridge	0	0	8
Lynn Lake	0	0	5
Meadow Lake	0	1	7
Medicine Hat	0	0	8
Moose Jaw	0	0	8
Nipawin	1	0	7
North Battleford	0	0	8
Norway House	0	0	6
Peace River	0	0	8
Pincher Creek	0	0	8
Portage La Prairie	0	0	8
Prince Albert	1	0	7
Red Deer	0	0	8
Regina	0	0	8

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	0	1	7
Saskatoon	0	0	8
Slave Lake	2	0	6
Swift Current	0	0	8
The Pas	0	0	6
Thompson	1	0	4
Whitecourt	0	0	8
Winnipeg	0	0	8
Wynyard	0	0	8
Yorkton	0	0	8

Table D11: Location summary of 40-year water vapour pressure trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	1	7
Broadview	1	0	7
Calgary	0	0	8
Churchill	0	0	4
Cold Lake	0	0	8
Coronation	0	2	6
Dauphin	0	0	8
Edmonton Intl	1	0	7
Edmonton Mun	1	0	7
Edson	0	1	7
Estevan	0	1	7
Fort McMurray	0	0	6
Fort Nelson	0	0	5
Fort St John	1	0	7
Gimli	0	1	7
Grande Prairie	1	1	6
Jasper	0	0	8
Kindersley	0	0	8
Lethbridge	0	1	7
Medicine Hat	0	0	8
Moose Jaw	0	1	7
North Battleford	0	0	8
Peace River	1	0	7
Pincher Creek	0	1	7
Portage La Prairie	0	1	7
Prince Albert	0	0	8
Red Deer	0	1	7
Regina	0	0	8
Rocky Mtn House	0	2	6
Saskatoon	0	0	8
Swift Current	0	1	7
The Pas	0	0	6
Whitecourt	2	0	6
Winnipeg	0	0	8
Wynyard	0	0	8
Yorkton	0	1	7

Table D12: Location summary of 50-year water vapour pressure trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	1	7
Broadview	2	0	6
Calgary	1	0	7
Churchill	0	0	4
Cold Lake	0	0	8
Coronation	1	1	6
Dauphin	0	0	8
Edmonton Mun	2	0	6
Estevan	0	1	7
Fort McMurray	1	0	5
Fort Nelson	1	0	4
Fort St John	1	0	7
Gimli	0	1	7
Grande Prairie	2	0	6
Lethbridge	1	0	7
Medicine Hat	1	0	7
Moose Jaw	0	1	7
North Battleford	0	0	8
Peace River	2	0	6
Portage La Prairie	0	1	7
Prince Albert	2	0	6
Red Deer	0	0	8
Regina	0	0	8
Rocky Mtn House	0	1	7
Saskatoon	0	0	8
Swift Current	1	0	7
The Pas	0	0	6
Whitecourt	4	0	4
Winnipeg	0	0	8
Yorkton	0	1	7

Table D13: Location summary of 30-year V_w-V_a trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	2	6
Broadview	0	1	7
Buffalo Narrows	0	0	6
Calgary	0	3	5
Churchill	0	1	3
Cold Lake	0	1	7
Coronation	0	1	7
Dauphin	0	2	6
Edmonton Intl	1	0	7
Edmonton Mun	0	2	6
Edson	2	0	6
Estevan	0	1	7
Flin Flon	0	0	6
Fort McMurray	0	0	6
Fort Nelson	0	0	5
Fort St John	0	0	8
Gillam	0	0	5
Gimli	0	4	4
Grande Prairie	1	0	7
High Level	0	0	5
Island Lake	0	0	6
Jasper	0	1	7
Kindersley	0	0	8
La Ronge	1	0	5
Lethbridge	0	1	7
Lynn Lake	0	0	5
Meadow Lake	0	0	8
Medicine Hat	0	0	8
Moose Jaw	0	3	5
Nipawin	3	0	5
North Battleford	0	1	7
Norway House	0	0	6
Peace River	1	0	7
Pincher Creek	0	0	8
Portage La Prairie	0	2	6
Prince Albert	0	0	8
Red Deer	0	0	8
Regina	0	1	7

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	0	1	7
Saskatoon	0	3	5
Slave Lake	2	0	6
Swift Current	0	3	5
The Pas	0	0	6
Thompson	0	0	5
Whitecourt	1	0	7
Winnipeg	0	3	5
Wynyard	0	3	5
Yorkton	0	3	5

Table D14: Location summary of 40-year V_w-V_a trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	1	1	6
Broadview	1	0	7
Calgary	0	0	8
Churchill	0	0	4
Cold Lake	1	0	7
Coronation	0	3	5
Dauphin	1	2	5
Edmonton Intl	0	0	8
Edmonton Mun	0	1	7
Edson	1	0	7
Estevan	0	0	8
Fort McMurray	1	0	5
Fort Nelson	0	0	5
Fort St John	1	0	7
Gimli	0	4	4
Grande Prairie	1	0	7
Jasper	1	1	6
Kindersley	1	0	7
Lethbridge	0	1	7
Medicine Hat	0	0	8
Moose Jaw	0	1	7
North Battleford	1	1	6
Peace River	2	0	6
Pincher Creek	0	1	7
Portage La Prairie	1	1	6
Prince Albert	3	0	5
Red Deer	0	2	6
Regina	0	1	7
Rocky Mtn House	0	1	7
Saskatoon	0	1	7
Swift Current	0	2	6
The Pas	0	0	6
Whitecourt	0	0	8
Winnipeg	1	1	6
Wynyard	0	1	7
Yorkton	0	1	7

Table D15: Location summary of 50-year V_w-V_a trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	1	1	6
Broadview	1	0	7
Calgary	2	0	6
Churchill	2	0	2
Cold Lake	1	0	7
Coronation	1	0	7
Dauphin	2	0	6
Edmonton Mun	1	0	7
Estevan	0	0	8
Fort McMurray	3	0	3
Fort Nelson	0	0	5
Fort St John	1	0	7
Gimli	0	2	6
Grande Prairie	1	0	7
Lethbridge	1	0	7
Medicine Hat	1	0	7
Moose Jaw	0	1	7
North Battleford	1	0	7
Peace River	2	0	6
Portage La Prairie	1	1	6
Prince Albert	5	0	3
Red Deer	1	0	7
Regina	2	0	6
Rocky Mtn House	0	1	7
Saskatoon	1	1	6
Swift Current	1	0	7
The Pas	5	0	1
Whitecourt	0	0	8
Winnipeg	1	1	6
Yorkton	1	1	6

Table D16: Location summary of 30-year wind speed trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	2	6
Broadview	5	0	3
Buffalo Narrows	7	0	1
Calgary	0	0	8
Churchill	0	0	7
Cold Lake	0	0	8
Coronation	0	6	2
Dauphin	0	7	1
Edmonton Intl	0	1	7
Edmonton Mun	1	0	7
Edson	0	0	8
Estevan	0	6	2
Flin Flon	0	0	8
Fort McMurray	0	2	6
Fort Nelson	1	0	7
Fort St John	0	4	4
Gillam	0	1	6
Gimli	3	0	5
Grande Prairie	0	0	8
High Level	4	0	4
Island Lake	0	0	8
Jasper	0	8	0
Kindersley	3	0	5
La Ronge	2	0	6
Lethbridge	0	0	8
Lynn Lake	0	6	1
Meadow Lake	8	0	0
Medicine Hat	0	8	0
Moose Jaw	0	1	7
Nipawin	2	0	6
North Battleford	0	3	5
Norway House	0	8	0
Peace River	0	0	8
Pincher Creek	1	1	6
Portage La Prairie	0	6	2
Prince Albert	0	6	2
Red Deer	0	8	0
Regina	0	0	8

Location	Trend		
	Increasing	Decreasing	No trend
Rocky Mtn House	0	6	2
Saskatoon	0	6	2
Slave Lake	0	0	8
Swift Current	0	0	8
The Pas	0	1	7
Thompson	0	0	7
Whitecourt	0	0	8
Winnipeg	0	0	8
Wynyard	0	8	0
Yorkton	0	2	6

Table D17: Location summary of 40-year wind speed trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	1	7
Broadview	0	0	8
Calgary	0	0	8
Churchill	0	0	7
Cold Lake	0	8	0
Coronation	0	0	8
Dauphin	0	7	1
Edmonton Intl	0	8	0
Edmonton Mun	0	0	8
Edson	0	3	5
Estevan	0	6	2
Fort McMurray	0	2	6
Fort Nelson	0	0	8
Fort St John	0	8	0
Gimli	0	1	7
Grande Prairie	0	5	3
Jasper	0	8	0
Kindersley	0	0	8
Lethbridge	0	2	6
Medicine Hat	0	6	2
Moose Jaw	0	8	0
North Battleford	0	4	4
Peace River	0	0	8
Pincher Creek	0	0	8
Portage La Prairie	0	8	0
Prince Albert	0	8	0
Red Deer	0	8	0
Regina	0	7	1
Rocky Mtn House	0	6	2
Saskatoon	0	2	6
Swift Current	0	8	0
The Pas	0	8	0
Whitecourt	0	0	8
Winnipeg	0	2	6
Wynyard	0	8	0
Yorkton	0	8	0

Table D18: Location summary of 50-year wind speed trends (5% level)

Location	Trend		
	Increasing	Decreasing	No trend
Brandon	0	2	6
Broadview	0	0	8
Calgary	0	0	8
Churchill	0	0	7
Cold Lake	0	8	0
Coronation	0	0	8
Dauphin	0	4	4
Edmonton Mun	0	1	7
Estevan	0	4	4
Fort McMurray	0	1	7
Fort Nelson	0	4	4
Fort St John	0	8	0
Gimli	0	4	4
Grande Prairie	0	8	0
Lethbridge	0	1	7
Medicine Hat	0	3	5
Moose Jaw	0	8	0
North Battleford	0	6	2
Peace River	7	0	1
Portage La Prairie	0	8	0
Prince Albert	0	7	1
Red Deer	0	8	0
Regina	0	1	7
Rocky Mtn House	0	7	1
Saskatoon	0	0	8
Swift Current	0	7	1
The Pas	0	8	0
Whitecourt	0	5	3
Winnipeg	0	3	5
Yorkton	0	8	0

Appendix E

Percentages of Stations with Trends at the 5% Significance Level

Table E1: Percentage of stations with air temperature trends from 1971-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	0.00%	0.00%	2.08%	2.08%	8.33%	0.00%	0.00%	0.00%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	6.25%	0.00%
No trend	100%	100%	97.92%	97.92%	91.67%	100%	93.75%	100%

Table E2: Percentage of stations with air temperature trends from 1961-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	20.00%	2.78%	0.00%	0.00%	0.00%	0.00%	0.00%	2.78%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	50.00%	2.78%
No trend	80.00%	97.22%	100%	100%	100%	100%	50.00%	94.44%

Table E3: Percentage of stations with air temperature trends from 1951-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	48.28%	3.33%	23.33%	0.00%	0.00%	0.00%	0.00%	20.00%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	26.67%	0.00%
No trend	51.72%	96.67%	76.67%	100%	100%	100%	73.33%	80.00%

Table E4: Percentage of stations with dew point temperature trends from 1971-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	0.00%	0.00%	6.25%	41.67%	18.75%	8.33%	0.00%	18.75%
Decreasing	0.00%	2.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
No trend	100%	97.92%	93.75%	58.33%	81.25%	91.67%	100%	81.25%

Table E5: Percentage of stations with dew point temperature trends from 1961-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	2.86%	2.78%	8.33%	22.22%	11.11%	0.00%	0.00%	11.11%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.89%	0.00%
No trend	97.14%	97.22%	91.67%	77.78%	88.89%	100%	86.11%	88.89%

Table E6: Percentage of stations with dew point temperature trends from 1951-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	3.45%	3.33%	3.33%	3.33%	0.00%	0.00%	0.00%	3.33%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.33%	0.00%
No trend	96.55%	96.67%	96.67%	96.67%	100%	100%	86.67%	96.67%

Table E7: Percentage of stations with air vapour pressure trends from 1971-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	0.00%	0.00%	4.17%	45.83%	20.83%	8.33%	0.00%	41.67%
Decreasing	0.00%	2.08%	0.00%	0.00%	0.00%	0.00%	2.08%	0.00%
No trend	100%	97.92%	95.83%	54.17%	79.17%	91.67%	97.92%	58.33%

Table E8: Percentage of stations with air vapour pressure trends from 1961-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	2.86%	2.78%	8.33%	22.22%	8.33%	0.00%	0.00%	25.00%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	13.89%	0.00%
No trend	97.14%	97.22%	91.67%	77.78%	91.67%	100%	86.11%	75.00%

Table E9: Percentage of stations with air vapour pressure trends from 1951-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	3.45%	3.33%	3.33%	3.33%	0.00%	0.00%	0.00%	6.67%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	16.67%	0.00%
No trend	96.55%	96.67%	96.67%	96.67%	100%	100%	83.33%	93.33%

Table E10: Percentage of stations with water vapour pressure trends from 1971-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	0.00%	0.00%	2.08%	2.08%	8.33%	0.00%	0.00%	5.71%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.14%	0.00%
No trend	100%	100%	97.92%	97.92%	91.67%	100%	92.86%	94.29%

Table E11: Percentage of stations with water vapour pressure trends from 1961-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	18.75%	2.86%	0.00%	0.00%	0.00%	0.00%	0.00%	3.13%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	41.18%	6.25%
No trend	81.25%	97.14%	100%	100%	100%	100%	58.82%	90.63%

Table E12: Percentage of stations with water vapour pressure trends from 1951-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	38.46%	6.90%	23.33%	0.00%	0.00%	0.00%	0.00%	11.54%
Decreasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	28.57%	0.00%
No trend	61.54%	93.10%	76.67%	100%	100%	100%	71.43%	88.46%

Table E13: Percentage of stations with V_w-V_a trends from 1971-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	5.71%	2.13%	0.00%	0.00%	2.08%	12.50%	0.00%	5.71%
Decreasing	0.00%	2.13%	14.58%	31.25%	2.08%	4.17%	14.29%	31.43%
No trend	94.29%	95.74%	85.42%	68.75%	95.83%	83.33%	85.71%	62.86%

Table E14: Percentage of stations with V_w-V_a trends from 1961-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	43.75%	0.00%	0.00%	0.00%	0.00%	8.33%	0.00%	3.13%
Decreasing	0.00%	0.00%	8.33%	44.44%	2.78%	0.00%	11.76%	9.38%
No trend	56.25%	100%	91.67%	55.56%	97.22%	91.67%	88.24%	87.50%

Table E15: Percentage of stations with V_w-V_a trends from 1951-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	80.77%	6.90%	13.33%	6.67%	6.67%	20.00%	3.57%	3.85%
Decreasing	0.00%	0.00%	0.00%	23.33%	3.33%	0.00%	3.57%	0.00%
No trend	19.23%	93.10%	86.67%	70.00%	90.00%	80.00%	92.86%	96.15%

Table E16: Percentage of stations with wind speed trends from 1971-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	9.09%	12.50%	8.33%	4.17%	8.33%	12.50%	8.33%	14.58%
Decreasing	25.00%	25.00%	25.00%	37.50%	29.17%	22.92%	25.00%	35.42%
No trend	65.91%	62.50%	66.67%	58.33%	62.50%	64.58%	66.67%	50.00%

Table E17: Percentage of stations with wind speed trends from 1961-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Decreasing	54.29%	52.78%	38.89%	47.22%	50.00%	50.00%	55.56%	69.44%
No trend	45.71%	47.22%	61.11%	52.78%	50.00%	50.00%	44.44%	30.56%

Table E18: Percentage of stations with wind speed trends from 1951-2000 (5% level)

Trend	April	May	June	July	August	September	October	Mean
Increasing	3.45%	3.33%	3.33%	3.33%	0.00%	3.33%	3.33%	3.33%
Decreasing	48.28%	56.67%	43.33%	60.00%	40.00%	53.33%	46.67%	66.67%
No trend	48.28%	40.00%	53.33%	36.67%	60.00%	43.33%	50.00%	30.00%

Appendix F

Comparison of Gross Evaporation and Input Variable Trends

Table F1: Comparison of 30-year gross evaporation and air temperature trends (10% level)

Type	Air temperature trend	Gross evaporation trend	Frequency
1	increasing	none	21
2	decreasing	none	3
3	none	increasing	31
4	none	decreasing	98
5	decreasing	decreasing	6
6	increasing	increasing	1
7	none	none	220
8	increasing	decreasing	0
9	decreasing	increasing	0

Table F2: Comparison of 40-year gross evaporation and air temperature trends (10% level)

Type	Air temperature trend	Gross evaporation trend	Frequency
1	increasing	none	17
2	decreasing	none	6
3	none	increasing	7
4	none	decreasing	89
5	decreasing	decreasing	20
6	increasing	increasing	5
7	none	none	142
8	increasing	decreasing	1
9	decreasing	increasing	0

Table F3: Comparison of 50-year gross evaporation and air temperature trends (10% level)

Type	Air temperature trend	Gross evaporation trend	Frequency
1	increasing	none	23
2	decreasing	none	6
3	none	increasing	11
4	none	decreasing	52
5	decreasing	decreasing	7
6	increasing	increasing	18
7	none	none	122
8	increasing	decreasing	0
9	decreasing	increasing	0

Table F4: Comparison of 30-year gross evaporation and dew point temperature trends (10% level)

Type	Dew point temperature trend	Gross evaporation trend	Frequency
1	increasing	none	39
2	decreasing	none	1
3	none	increasing	31
4	none	decreasing	61
5	decreasing	decreasing	0
6	increasing	increasing	0
7	none	none	204
8	increasing	decreasing	43
9	decreasing	increasing	1

Table F5: Comparison of 40-year gross evaporation and dew point temperature trends (10% level)

Type	Dew point temperature trend	Gross evaporation trend	Frequency
1	increasing	none	15
2	decreasing	none	10
3	none	increasing	12
4	none	decreasing	83
5	decreasing	decreasing	3
6	increasing	increasing	0
7	none	none	140
8	increasing	decreasing	24
9	decreasing	increasing	0

Table F6: Comparison of 50-year gross evaporation and dew point temperature trends (10% level)

Type	Dew point temperature trend	Gross evaporation trend	Frequency
1	increasing	none	6
2	decreasing	none	12
3	none	increasing	28
4	none	decreasing	50
5	decreasing	decreasing	3
6	increasing	increasing	0
7	none	none	133
8	increasing	decreasing	6
9	decreasing	increasing	1

Table F7: Comparison of 30-year gross evaporation and air vapour pressure trends (10% level)

Type	V_a trend	Gross evaporation trend	Frequency
1	increasing	none	44
2	decreasing	none	1
3	none	increasing	31
4	none	decreasing	57
5	decreasing	decreasing	0
6	increasing	increasing	0
7	none	none	199
8	increasing	decreasing	47
9	decreasing	increasing	1

Table F8: Comparison of 40-year gross evaporation and air vapour pressure trends (10% level)

Type	V_a trend	Gross evaporation trend	Frequency
1	increasing	none	17
2	decreasing	none	10
3	none	increasing	12
4	none	decreasing	78
5	decreasing	decreasing	4
6	increasing	increasing	0
7	none	none	138
8	increasing	decreasing	28
9	decreasing	increasing	0

Table F9: Comparison of 50-year gross evaporation and air vapour pressure trends (10% level)

Type	V_a trend	Gross evaporation trend	Frequency
1	increasing	none	6
2	decreasing	none	10
3	none	increasing	28
4	none	decreasing	47
5	decreasing	decreasing	3
6	increasing	increasing	0
7	none	none	135
8	increasing	decreasing	9
9	decreasing	increasing	1

Table F10: Comparison of 30-year gross evaporation and water vapour pressure trends (10% level)

Type	V_w trend	Gross evaporation trend	Frequency
1	increasing	none	19
2	decreasing	none	1
3	none	increasing	27
4	none	decreasing	97
5	decreasing	decreasing	5
6	increasing	increasing	2
7	none	none	200
8	increasing	decreasing	0
9	decreasing	increasing	0

Table F11: Comparison of 40-year gross evaporation and water vapour pressure trends (10% level)

Type	V_w trend	Gross evaporation trend	Frequency
1	increasing	none	16
2	decreasing	none	7
3	none	increasing	7
4	none	decreasing	88
5	decreasing	decreasing	19
6	increasing	increasing	5
7	none	none	134
8	increasing	decreasing	1
9	decreasing	increasing	0

Table F12: Comparison of 50-year gross evaporation and water vapour pressure trends (10% level)

Type	V_w trend	Gross evaporation trend	Frequency
1	increasing	none	22
2	decreasing	none	6
3	none	increasing	11
4	none	decreasing	50
5	decreasing	decreasing	8
6	increasing	increasing	15
7	none	none	117
8	increasing	decreasing	0
9	decreasing	increasing	0

Table F13: Comparison of 30-year gross evaporation and wind speed trends (10% level)

Type	Wind speed trend	Gross evaporation trend	Frequency
1	increasing	none	32
2	decreasing	none	58
3	none	increasing	10
4	none	decreasing	31
5	decreasing	decreasing	72
6	increasing	increasing	21
7	none	none	154
8	increasing	decreasing	1
9	decreasing	increasing	1

Table F14: Comparison of 40-year gross evaporation and wind speed trends (10% level)

Type	Wind speed trend	Gross evaporation trend	Frequency
1	increasing	none	0
2	decreasing	none	68
3	none	increasing	8
4	none	decreasing	21
5	decreasing	decreasing	89
6	increasing	increasing	0
7	none	none	97
8	increasing	decreasing	0
9	decreasing	increasing	4

Table F15: Comparison of 50-year gross evaporation and wind speed trends (10% level)

Type	Wind speed trend	Gross evaporation trend	Frequency
1	increasing	none	2
2	decreasing	none	79
3	none	increasing	11
4	none	decreasing	7
5	decreasing	decreasing	52
6	increasing	increasing	6
7	none	none	70
8	increasing	decreasing	0
9	decreasing	increasing	12

Appendix G

Comparison of Selected Input Variables

Table G1: Comparison of 30-year air vapour pressure (V_a) and dew point temperature trends (10% level)

Type	V_a trend	Dew point temperature trend	Frequency
1	increasing	none	9
2	decreasing	none	0
3	none	increasing	0
4	none	decreasing	0
5	decreasing	decreasing	2
6	increasing	increasing	82
7	none	none	287
8	decreasing	increasing	0
9	increasing	decreasing	0

Table G2: Comparison of 40-year air vapour pressure (V_a) and dew point temperature trends (10% level)

Type	V_a trend	Dew point temperature trend	Frequency
1	increasing	none	6
2	decreasing	none	1
3	none	increasing	0
4	none	decreasing	0
5	decreasing	decreasing	13
6	increasing	increasing	39
7	none	none	228
8	decreasing	increasing	0
9	increasing	decreasing	0

Table G3: Comparison of 50-year air vapour pressure (V_a) and dew point temperature trends (10% level)

Type	V_a trend	Dew point temperature trend	Frequency
1	increasing	none	3
2	decreasing	none	0
3	none	increasing	0
4	none	decreasing	2
5	decreasing	decreasing	14
6	increasing	increasing	12
7	none	none	208
8	decreasing	increasing	0
9	increasing	decreasing	0

Table G4: Comparison of 30-year water vapour pressure (V_W) and air temperature trends (10% level)

Type	V_w trend	Air temperature trend	Frequency
1	increasing	none	1
2	decreasing	none	1
3	none	increasing	1
4	none	decreasing	3
5	decreasing	decreasing	5
6	increasing	increasing	20
7	none	none	320
8	decreasing	increasing	0
9	increasing	decreasing	0

Table G5: Comparison of 40-year water vapour pressure (V_W) and air temperature trends (10% level)

Type	V_w trend	Air temperature trend	Frequency
1	increasing	none	2
2	decreasing	none	2
3	none	increasing	1
4	none	decreasing	1
5	decreasing	decreasing	24
6	increasing	increasing	20
7	none	none	227
8	decreasing	increasing	0
9	increasing	decreasing	0

Table G6: Comparison of 50-year water vapour pressure (V_W) and air temperature trends (10% level)

Type	V_w trend	Air temperature trend	Frequency
1	increasing	none	3
2	decreasing	none	1
3	none	increasing	3
4	none	decreasing	0
5	decreasing	decreasing	13
6	increasing	increasing	34
7	none	none	175
8	decreasing	increasing	0
9	increasing	decreasing	0

Appendix H

Correlations between Pan Evaporation and Input Variables

Table H1: Correlations between pan evaporation and input variables at Altawan/Medicine Hat

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	0.5239	0.5151	0.5735	0.4889	0.6319
Dew point temperature	-0.3192	0.1005	-0.3972	-0.3245	0.1158
Water vapour pressure	0.5221	0.5200	0.5728	0.4839	0.6308
Air vapour pressure	-0.3322	0.0923	-0.3942	-0.3019	0.1226
V_w-V_a	0.5945	0.4984	0.6714	0.6065	0.5754
Wind speed	-0.2072	0.3533	0.4761	0.0631	-0.0057

Table H2: Correlations between pan evaporation and input variables at Calgary Intl A/Calgary

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	--	0.6229	0.7507	0.6971	0.7585
Dew point temperature	--	-0.0273	-0.4617	-0.2725	-0.0144
Water vapour pressure	--	0.6268	0.7501	0.7000	0.7596
Air vapour pressure	--	-0.0314	-0.4529	-0.2631	-0.0081
V_w-V_a	--	0.6654	0.8714	0.8842	0.8761
Wind speed	--	0.4909	0.1955	0.0699	-0.3188

Table H3: Correlations between pan evaporation and input variables at Churchill/Churchill

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	--	--	0.8162	0.6453	--
Dew point temperature	--	--	0.6744	0.3803	--
Water vapour pressure	--	--	0.8267	0.6503	--
Air vapour pressure	--	--	0.6877	0.3907	--
V_w-V_a	--	--	0.7399	0.6420	--
Wind speed	--	--	0.2461	-0.1913	--

Table H4: Correlations between pan evaporation and input variables at Estevan A/Estevan

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	0.6981	0.8082	0.7371	0.7687	0.7192
Dew point temperature	-0.3415	-0.0532	-0.4102	-0.1022	0.1162
Water vapour pressure	0.6990	0.8149	0.7380	0.7743	0.7212
Air vapour pressure	-0.3182	-0.0691	-0.3914	-0.1133	0.1006
V_w-V_a	0.9148	0.8667	0.8663	0.8617	0.8263
Wind speed	0.1148	0.4924	0.5756	0.2010	0.2681

Table H5: Correlations between pan evaporation and input variables at Morden CDA/Portage La Prairie

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	0.8077	0.6223	0.6338	0.5657	0.6280
Dew point temperature	0.3358	0.0933	-0.0761	0.0010	0.1509
Water vapour pressure	0.8132	0.6321	0.6314	0.5629	0.6249
Air vapour pressure	0.3598	0.0800	-0.0874	-0.0021	0.1418
V_w-V_a	0.7463	0.7299	0.7358	0.6548	0.6484
Wind speed	-0.1078	0.1830	0.1405	0.0444	-0.0005

Table H6: Correlations between pan evaporation and input variables at Nipawin A/Nipawin

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	0.7509	0.5470	0.6977	0.8448	0.7231
Dew point temperature	0.0820	-0.0840	-0.1412	0.3357	0.0637
Water vapour pressure	0.7422	0.5538	0.6921	0.8441	0.7265
Air vapour pressure	0.0836	-0.0960	-0.1411	0.3411	0.0570
V_w-V_a	0.7636	0.7507	0.7500	0.8378	0.7960
Wind speed	0.1140	0.2401	0.3267	0.3285	0.4373

Table H7: Correlations between pan evaporation and input variables at Norway House Forestry/Norway House

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	--	0.3943	0.3921	0.4060	0.0404
Dew point temperature	--	0.1139	0.0355	0.2912	0.0685
Water vapour pressure	--	0.3976	0.3998	0.4005	0.0325
Air vapour pressure	--	0.1046	0.0378	0.2696	0.0591
V_w-V_a	--	0.5597	0.5294	0.2967	-0.0416
Wind speed	--	-0.0053	-0.0458	0.3939	0.1154

Table H8: Correlations between pan evaporation and input variables at Regina A/Regina

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	0.6943	0.7841	0.6835	0.7624	0.7747
Dew point temperature	-0.2091	-0.0348	-0.3618	-0.0080	0.1438
Water vapour pressure	0.6872	0.7934	0.6815	0.7623	0.7767
Air vapour pressure	-0.1877	-0.0567	-0.3463	-0.0189	0.1421
V_w-V_a	0.7993	0.8774	0.8502	0.8770	0.8396
Wind speed	0.3609	0.1493	0.2072	0.2141	0.1235

Table H9: Correlations between pan evaporation and input variables at Swift Current CDA/Swift Current

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	0.7551	0.7711	0.7292	0.8398	0.7872
Dew point temperature	-0.3651	-0.1917	-0.4954	-0.1000	0.0049
Water vapour pressure	0.7592	0.7804	0.7276	0.8396	0.7907
Air vapour pressure	-0.3603	-0.2055	-0.4771	-0.1058	0.0053
V_w-V_a	0.8949	0.9432	0.9424	0.9097	0.9370
Wind speed	0.1612	0.2170	0.4155	0.3122	-0.0608

Table H10: Correlations between pan evaporation and input variables at Weyburn/Regina

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	0.7065	0.7981	0.7507	0.7089	0.6910
Dew point temperature	-0.3561	-0.0141	-0.2945	-0.1291	0.0844
Water vapour pressure	0.7065	0.8121	0.7508	0.7116	0.6956
Air vapour pressure	-0.3373	-0.0344	-0.2826	-0.1399	0.0846
V_w-V_a	0.8869	0.8278	0.8200	0.8649	0.7867
Wind speed	0.1212	0.0752	0.0663	0.1216	0.0452

Table H11: Correlations between pan evaporation and input variables at Winnipeg Intl A/Winnipeg

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	0.6926	0.5513	0.6473	0.7115	0.6487
Dew point temperature	0.2364	0.0893	0.0449	0.1375	0.2003
Water vapour pressure	0.6923	0.5643	0.6485	0.7061	0.6594
Air vapour pressure	0.2634	0.0901	0.0431	0.1354	0.1887
V_w-V_a	0.7488	0.7998	0.8237	0.8446	0.7108
Wind speed	-0.1006	0.1347	0.2085	-0.0046	0.2916

Table H12: Correlations between pan evaporation and input variables at Wynyard/Wynyard

Input variable	May	Jun	Jul	Aug	Sep
Air temperature	0.7386	0.6738	0.7463	0.7870	0.6800
Dew point temperature	-0.1331	-0.1696	-0.3791	0.0764	0.0302
Water vapour pressure	0.7362	0.6858	0.7478	0.7911	0.6980
Air vapour pressure	-0.1220	-0.1823	-0.3765	0.0669	0.0249
V_w-V_a	0.9342	0.9243	0.9071	0.8827	0.9063
Wind speed	0.3488	0.4651	0.3572	0.4062	0.0694

Appendix I

Time-series Plots of Input Variables and Pan Evaporation

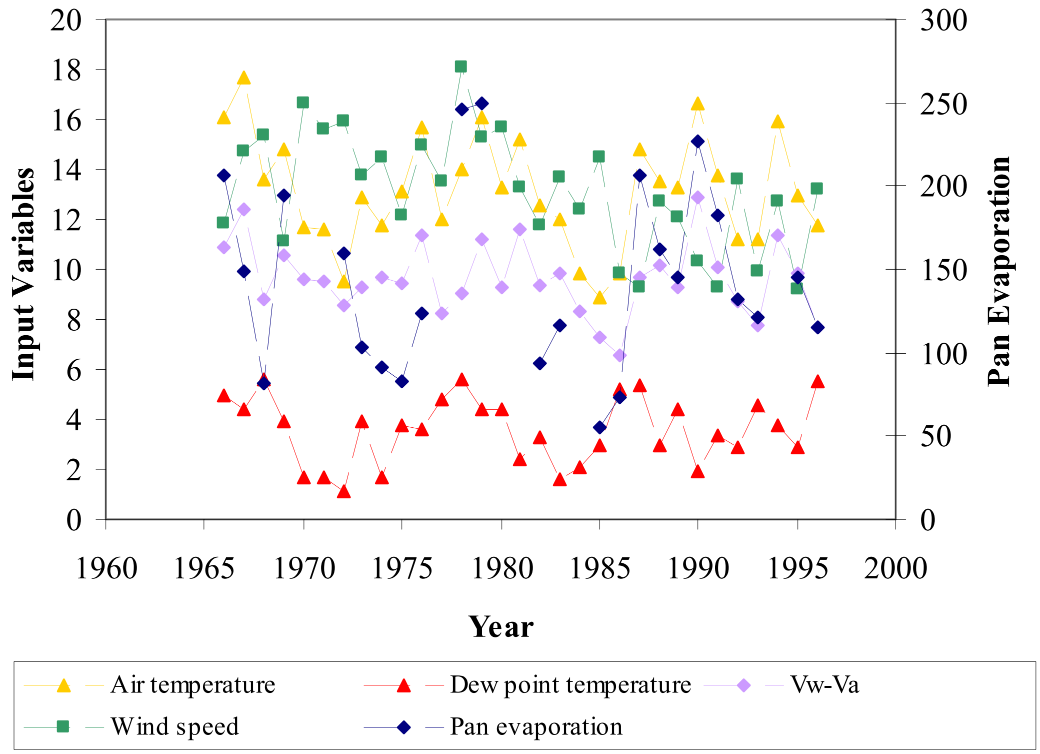

Figure I1: Time-series plot of pan evaporation and input variables at Altawan/Medicine Hat in September

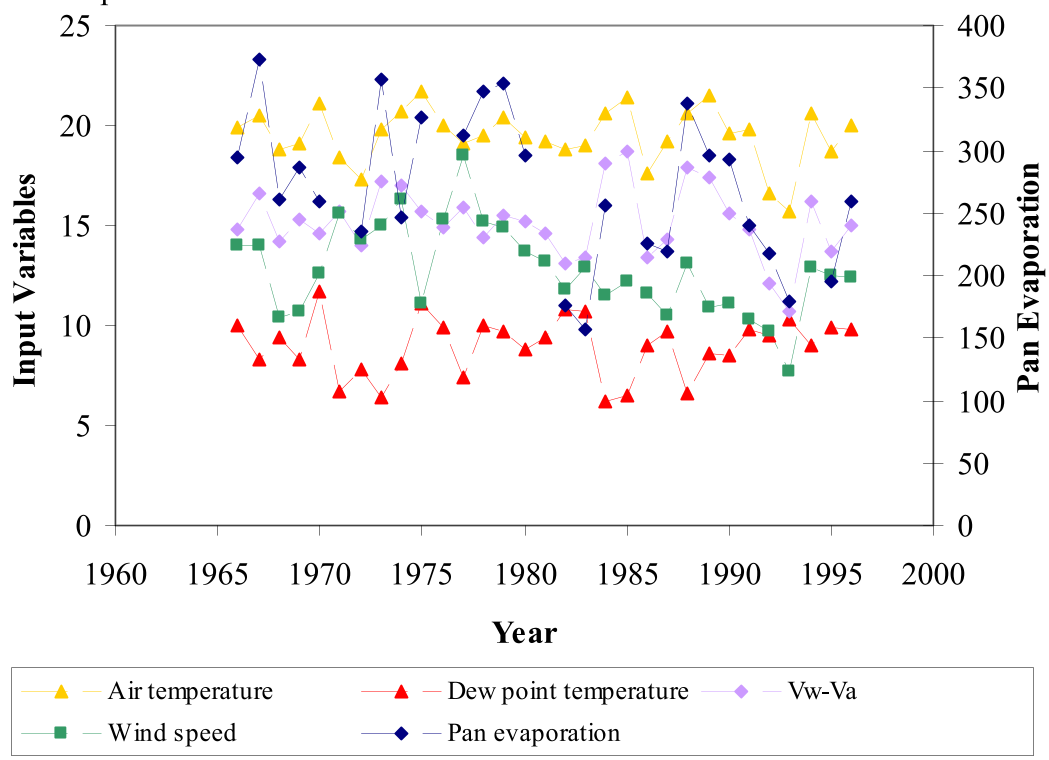

Figure I2: Time-series plot of pan evaporation and input variables at Altawan/Medicine Hat in July

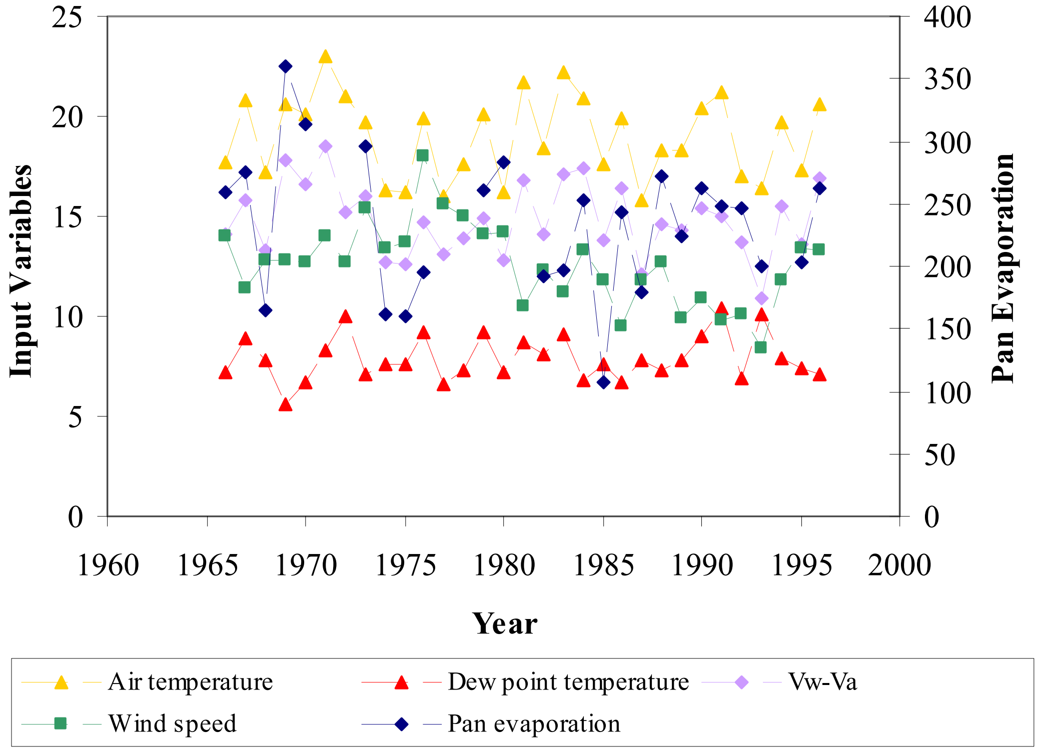

Figure I3: Time-series plot of pan evaporation and input variables at Altawan/Medicine Hat in August

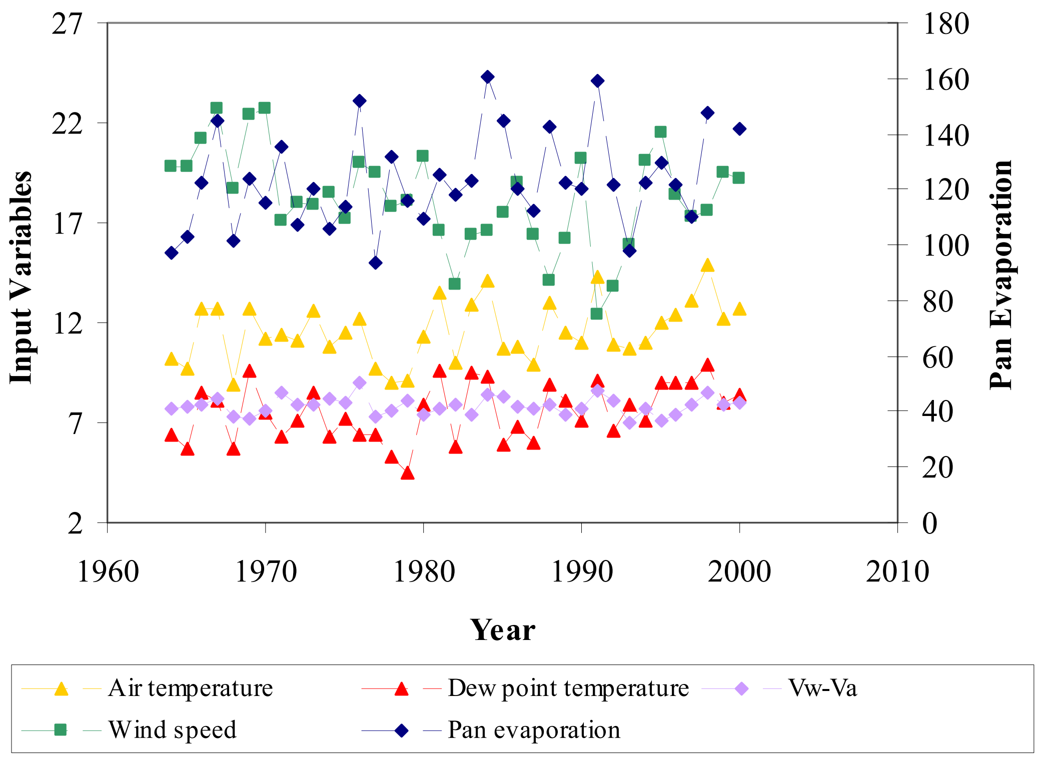

Figure I4: Time-series plot of pan evaporation and input variables at Churchill in August

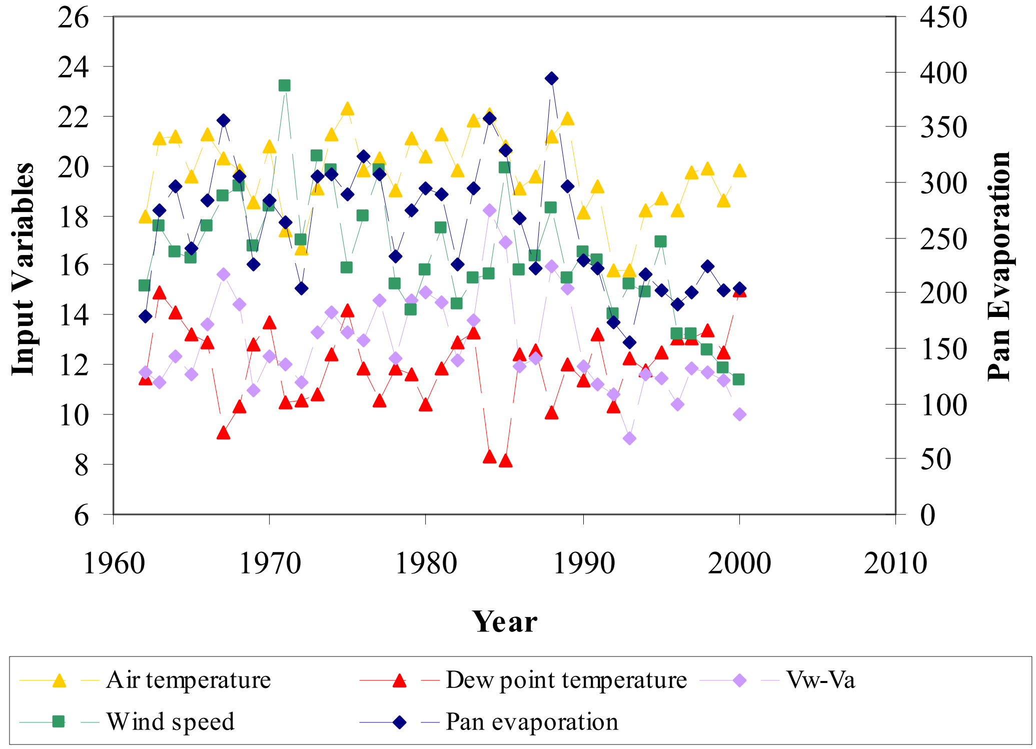

Figure I5: Time-series plot of pan evaporation and input variables at Estevan in July

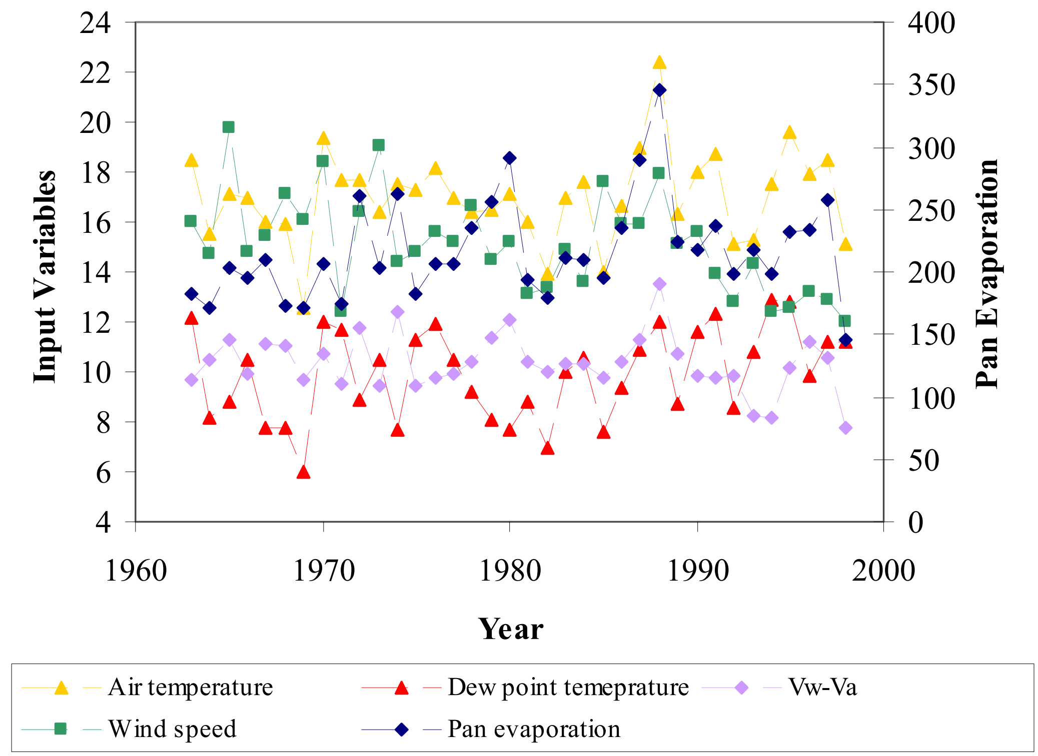

Figure I6: Time-series plot of pan evaporation and input variables at Morden/Portage La Prairies in June

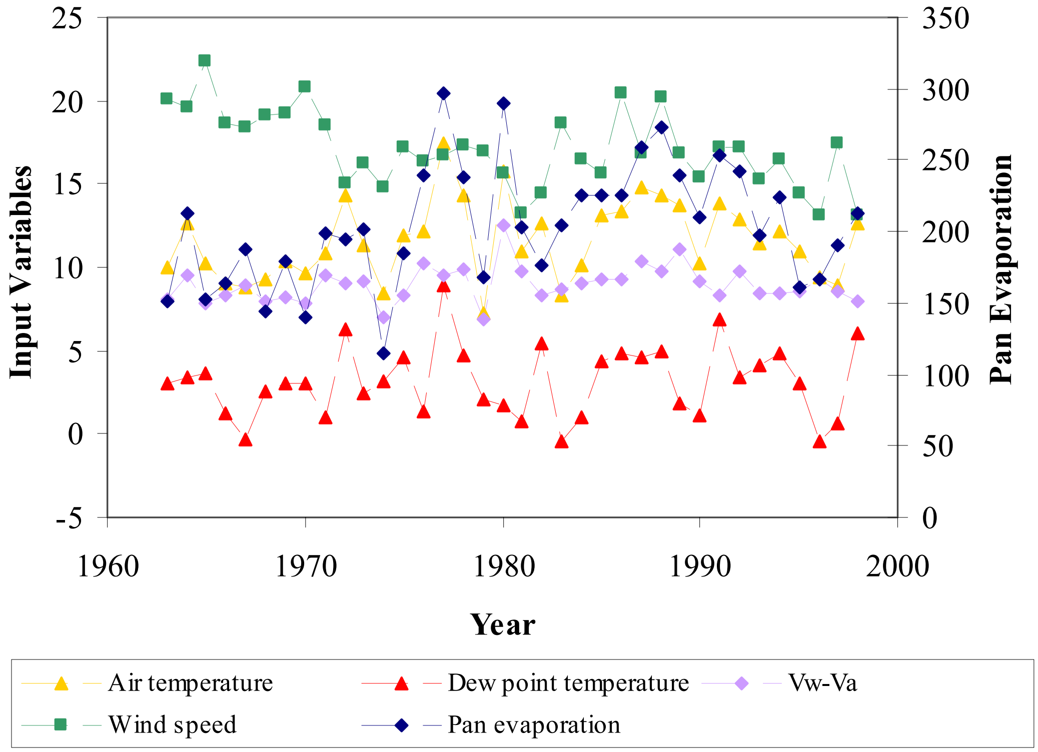

Figure I7: Time-series plot of pan evaporation and input variables at Morden/Portage La Prairie in May

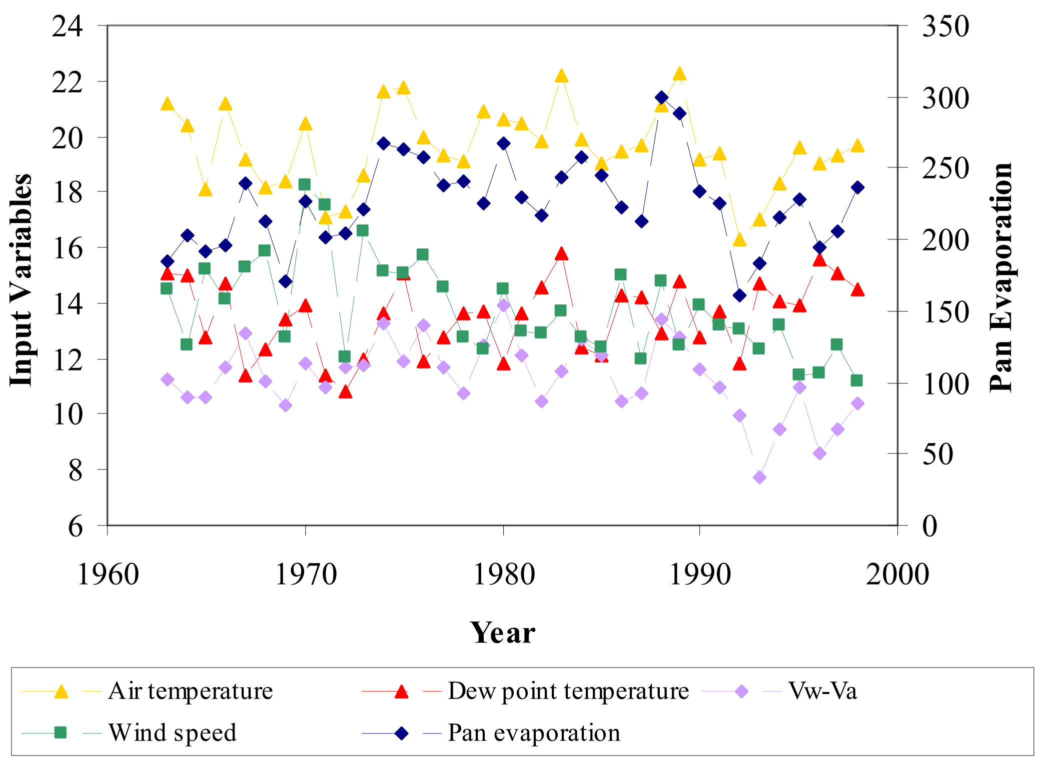

Figure I8: Time-series plot of pan evaporation and input variables at Morden/Portage La Prairie in July

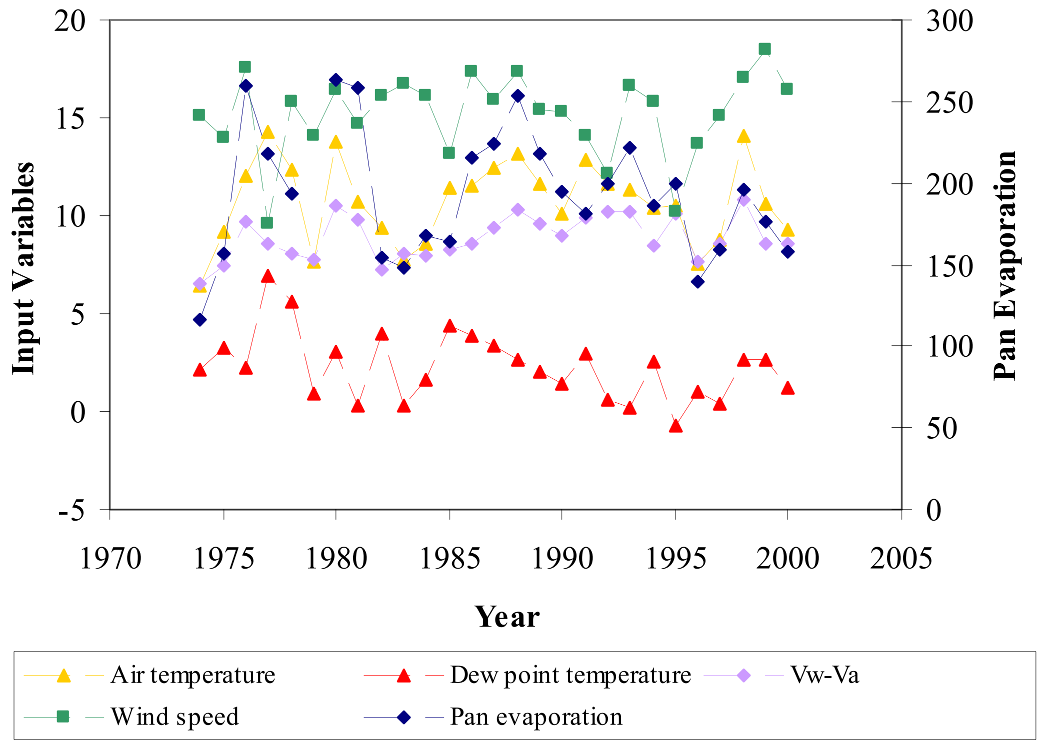

Figure I9: Time-series plot of pan evaporation and input variables at Nipawin in May

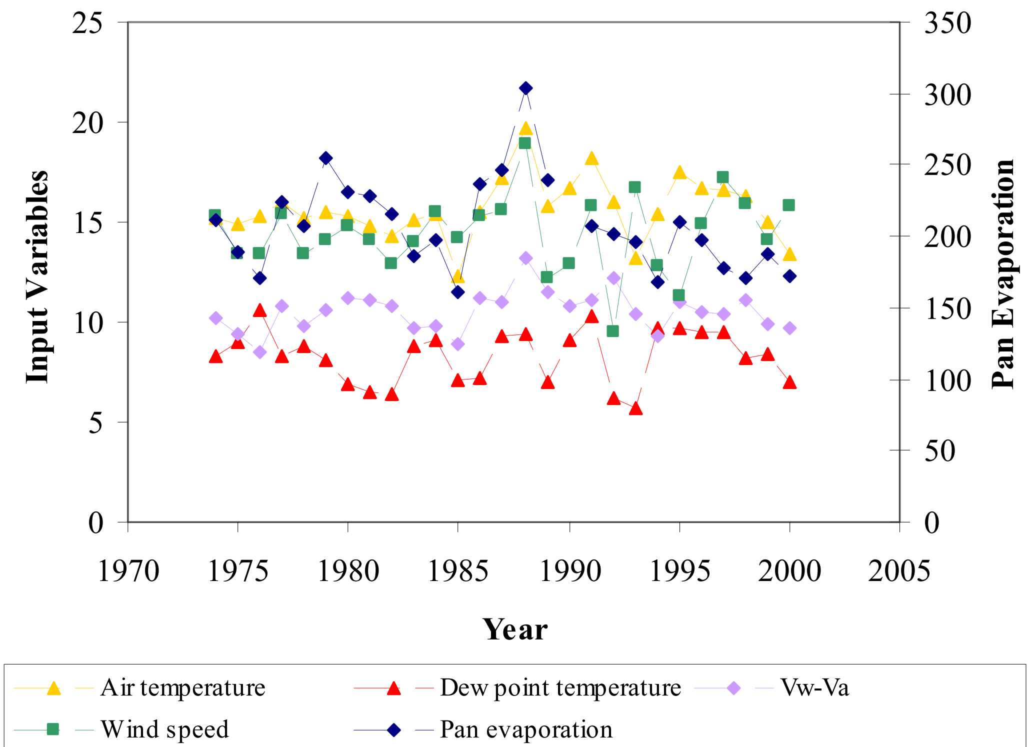

Figure I10: Time-series plot of pan evaporation and input variables at Nipawin in June

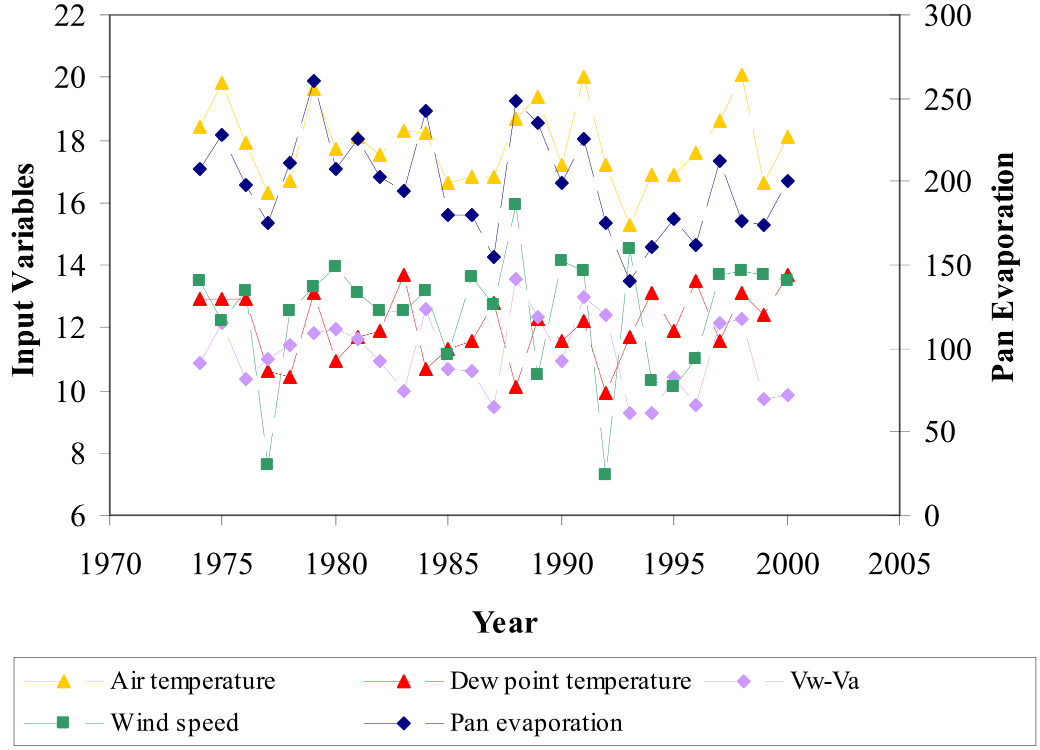

Figure I11: Time-series plot of pan evaporation and input variables at Nipawin in July

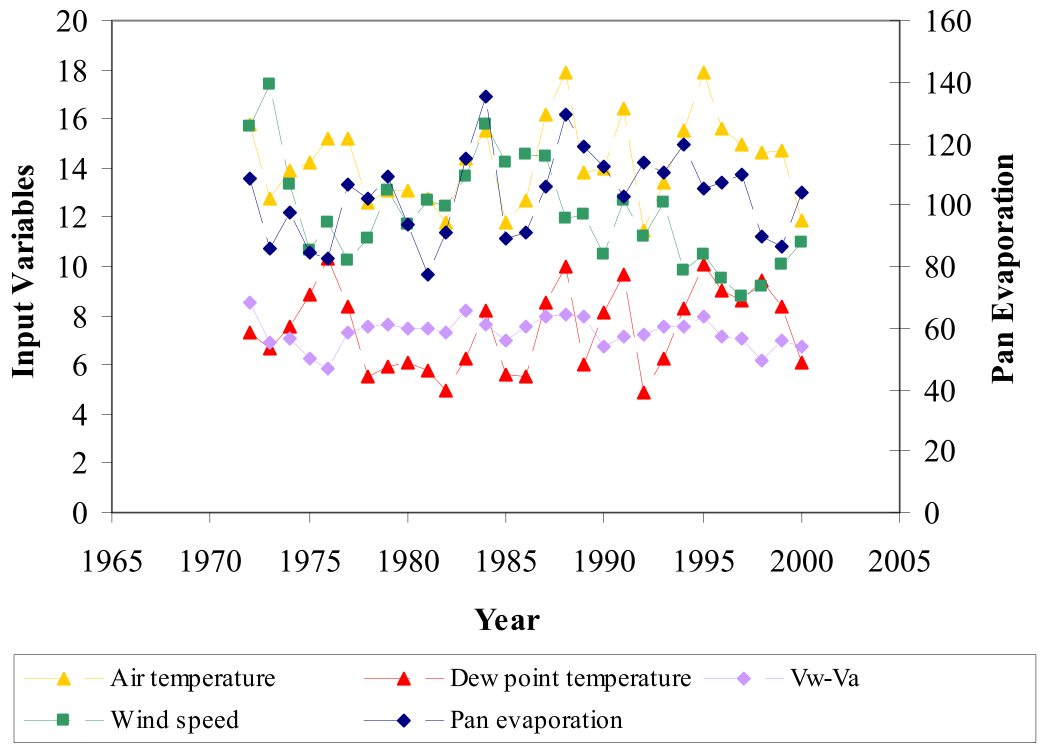

Figure I12: Time-series plot of pan evaporation and input variables at Norway House in June

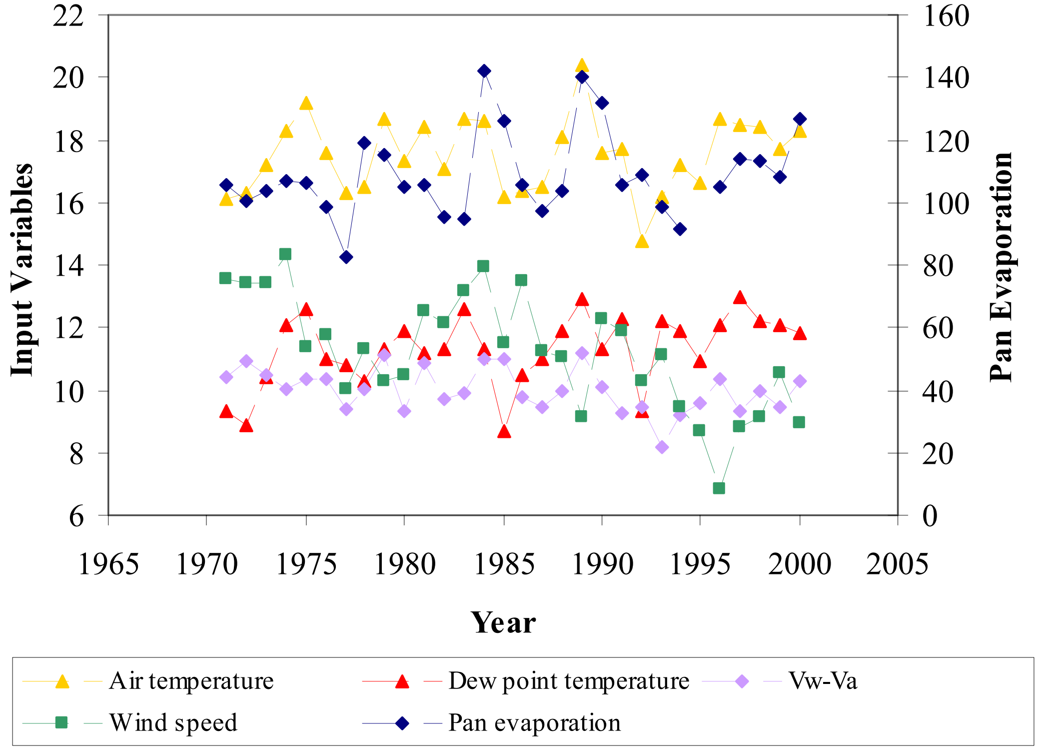

Figure I13: Time-series plot of pan evaporation and input variables at Norway House in July

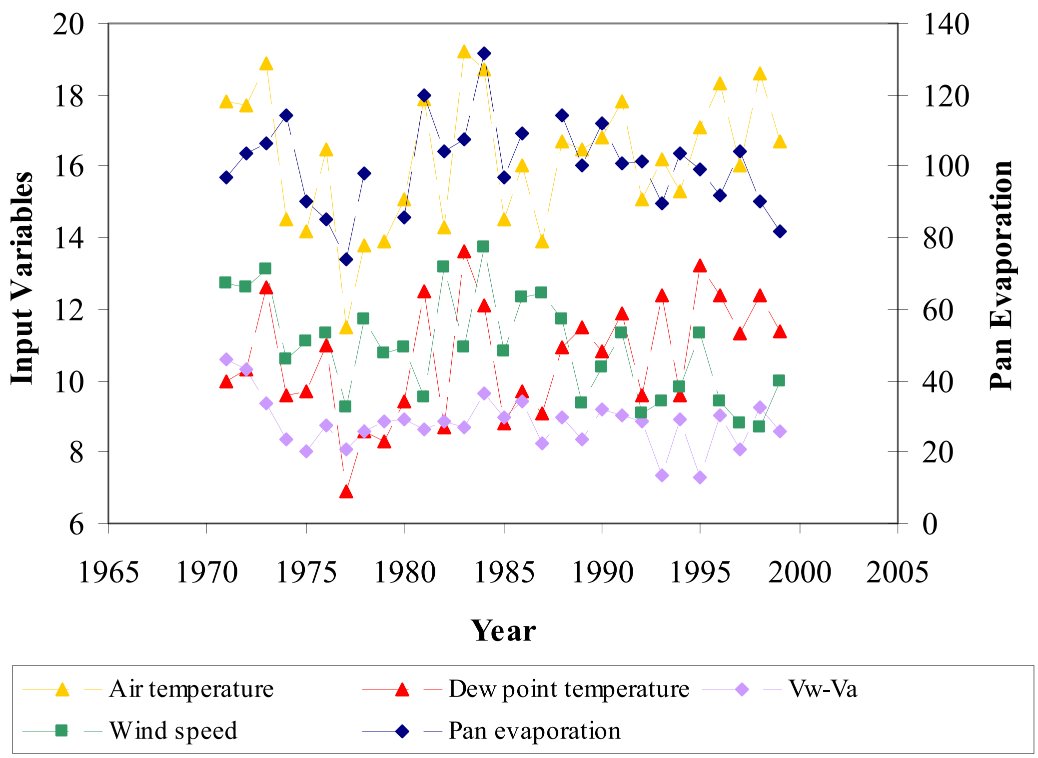

Figure I14: Time-series plot of pan evaporation and input variables at Norway House in August

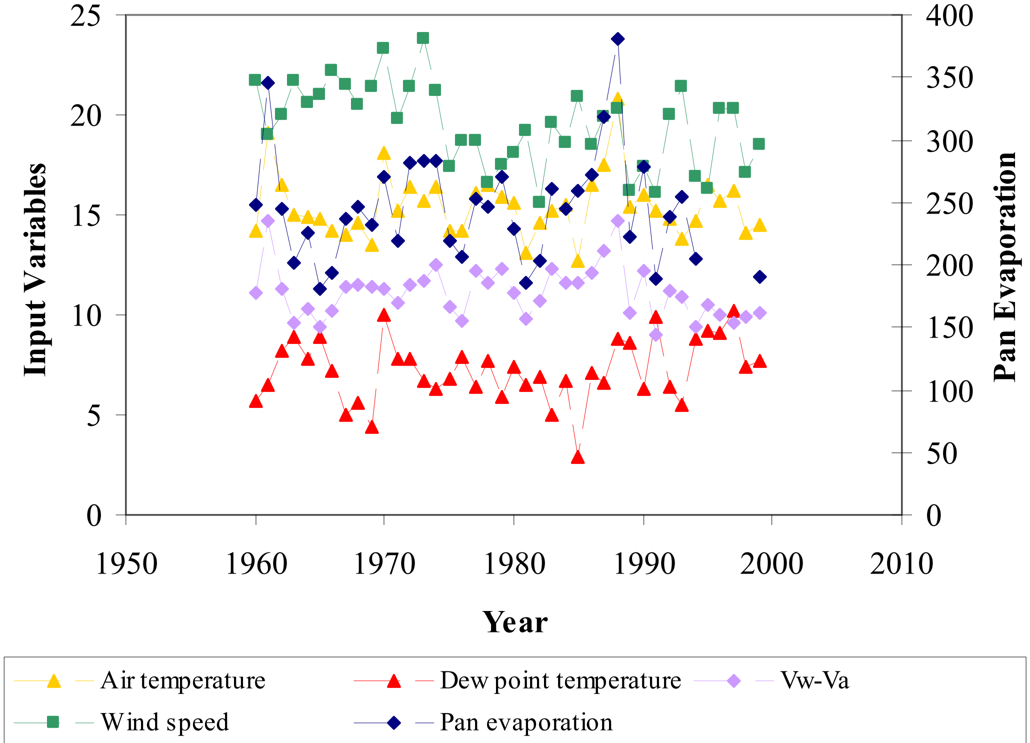

Figure I15: Time-series plot of pan evaporation and input variables at Swift Current in June

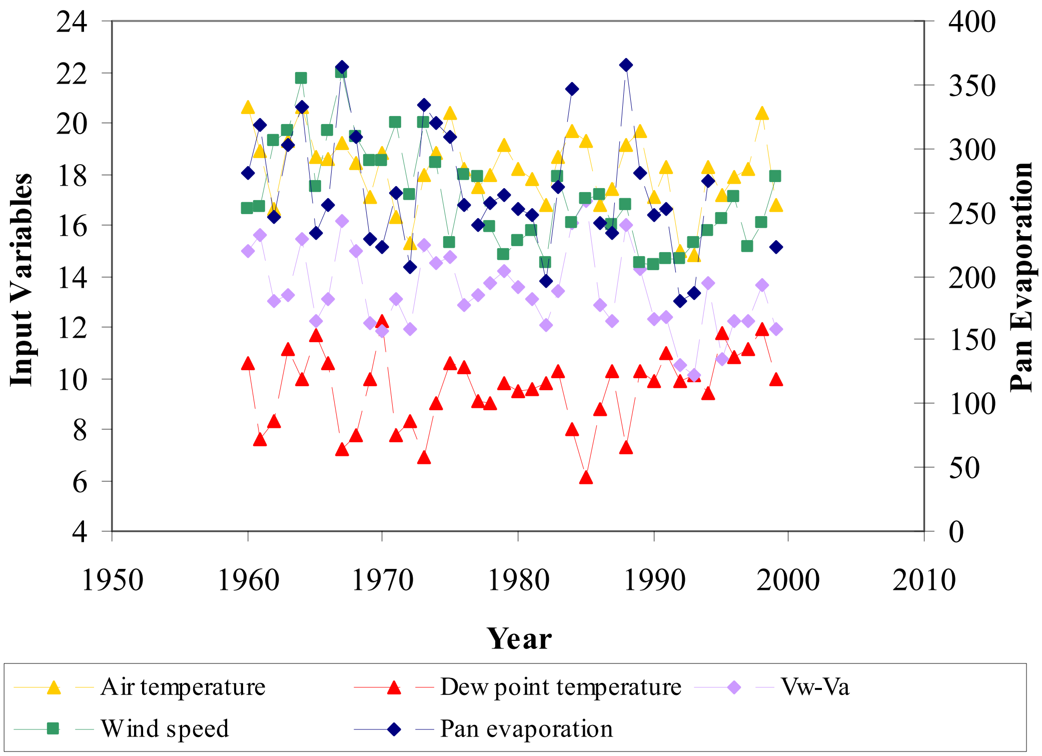

Figure I16: Time-series plot of pan evaporation and input variables at Swift Current in July

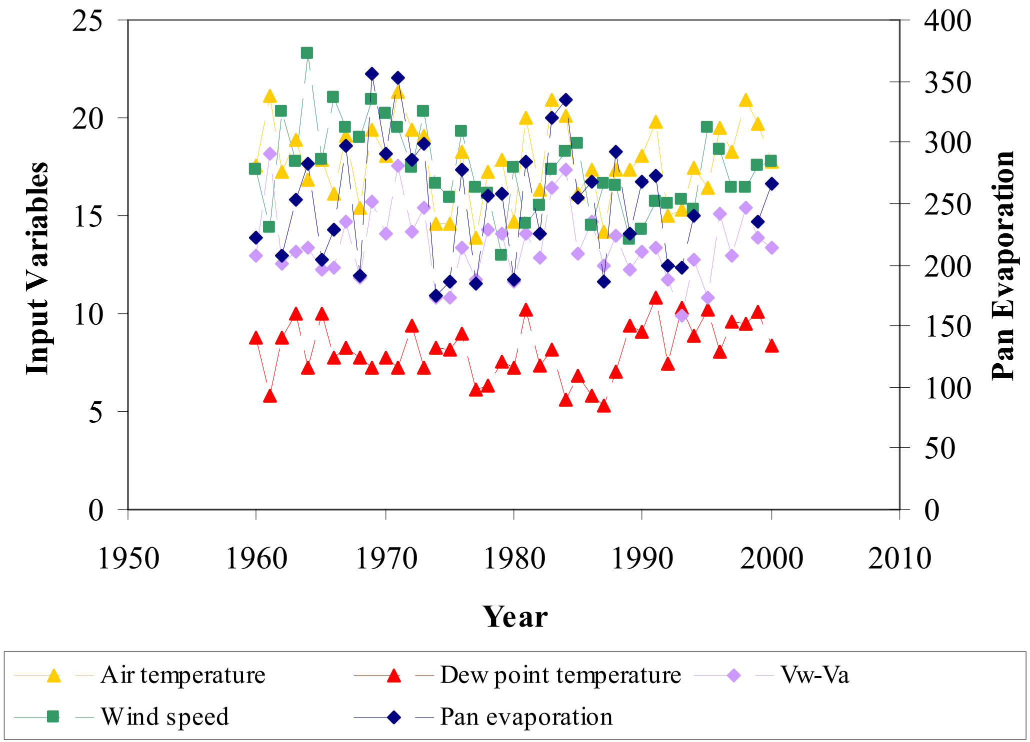

Figure I17: Time-series plot of pan evaporation and input variables at Swift Current in August

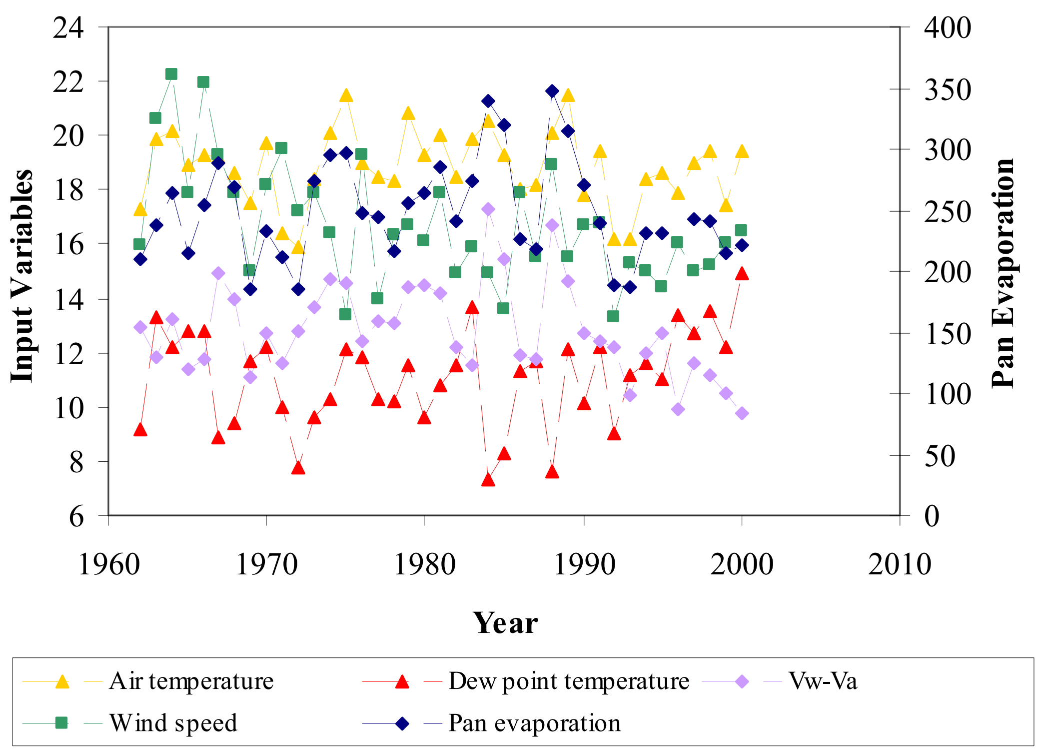

Figure I18: Time-series plot of pan evaporation and input variables at Weyburn/Regina in July

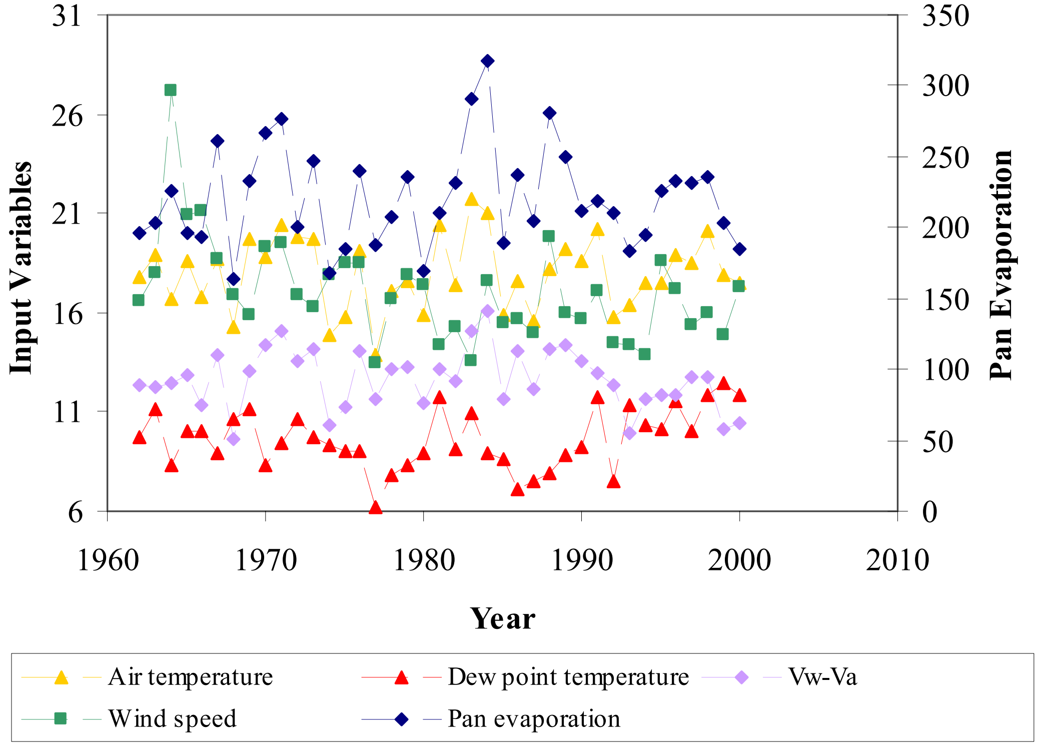

Figure I19: Time-series plot of pan evaporation and input variables at Weyburn/Regina in August

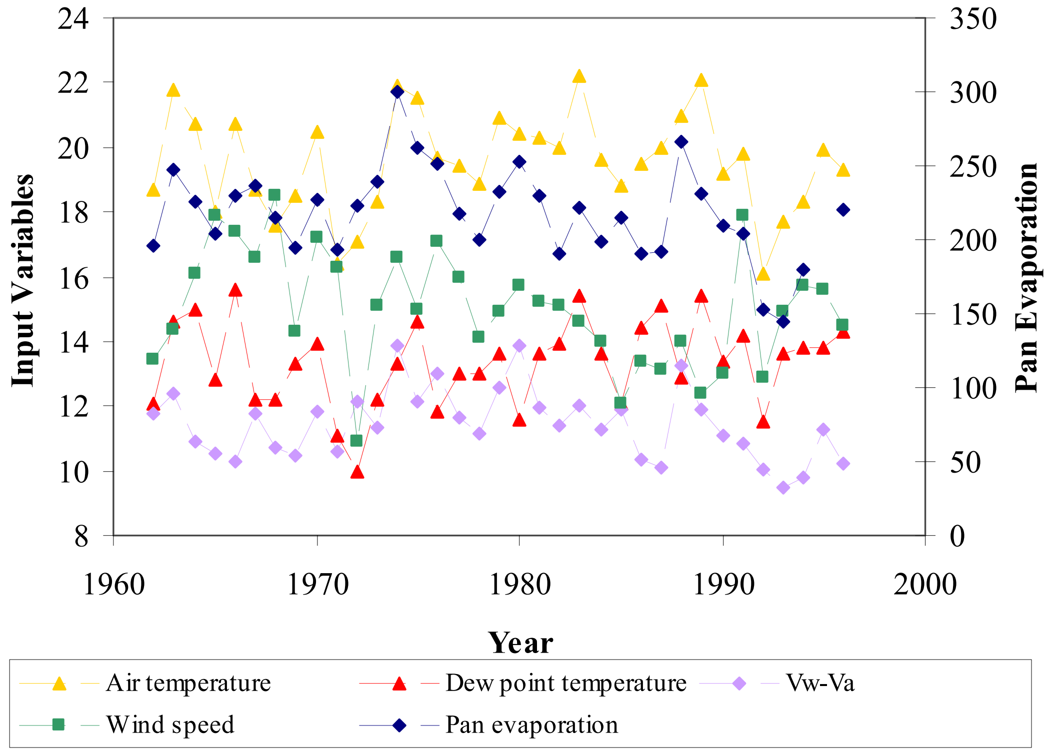

Figure I20: Time-series plot of pan evaporation and input variables at Winnipeg in July

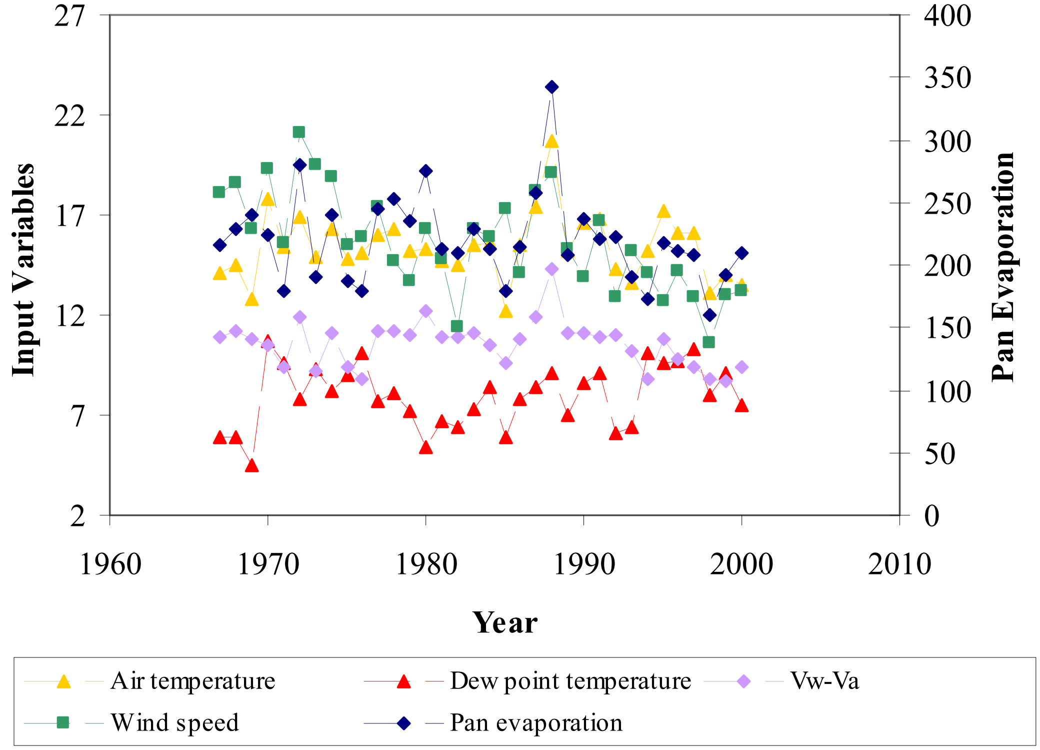

Figure I21: Time-series plot of pan evaporation and input variables at Wynyard in June

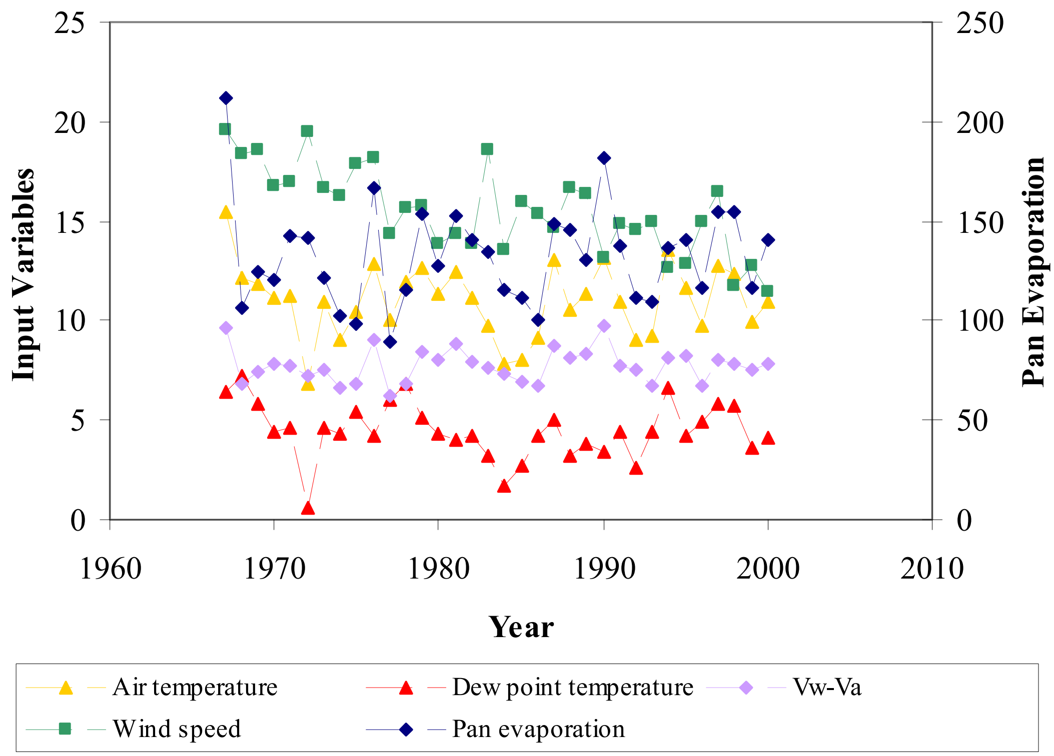

Figure I22: Time-series plot of pan evaporation and input variables at Wynyard in September

Appendix J

Time-series Plots of Input Variables and Gross Evaporation

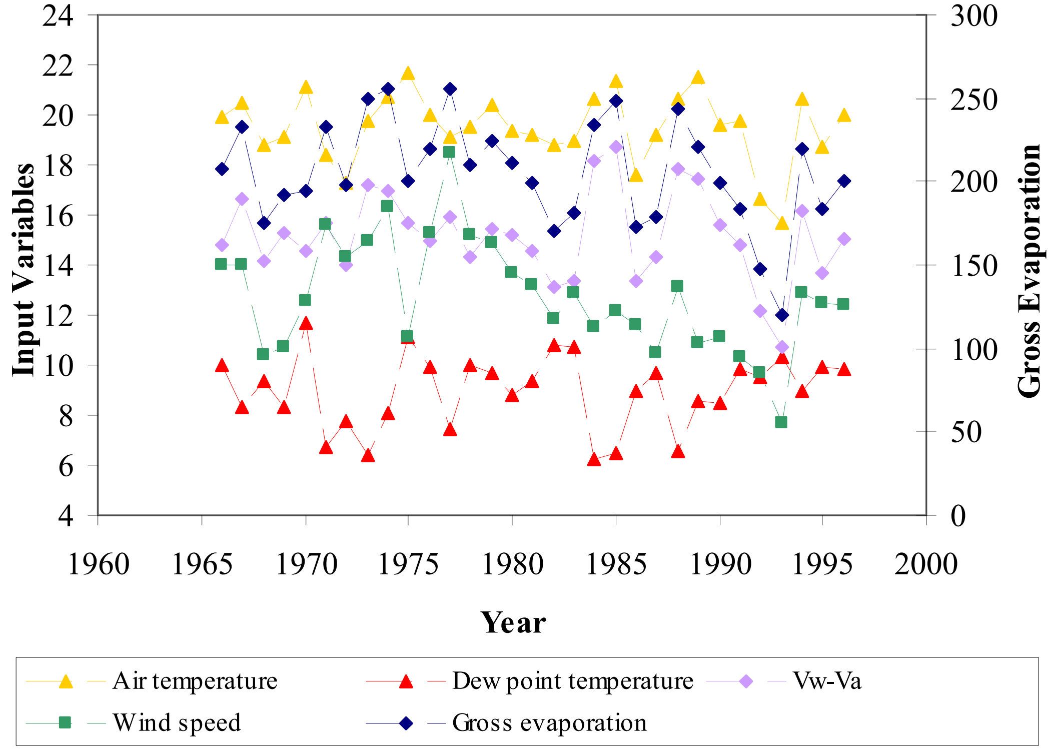

Figure J1: Time-series plot of gross evaporation and input variables at Altawan/Medicine Hat in July

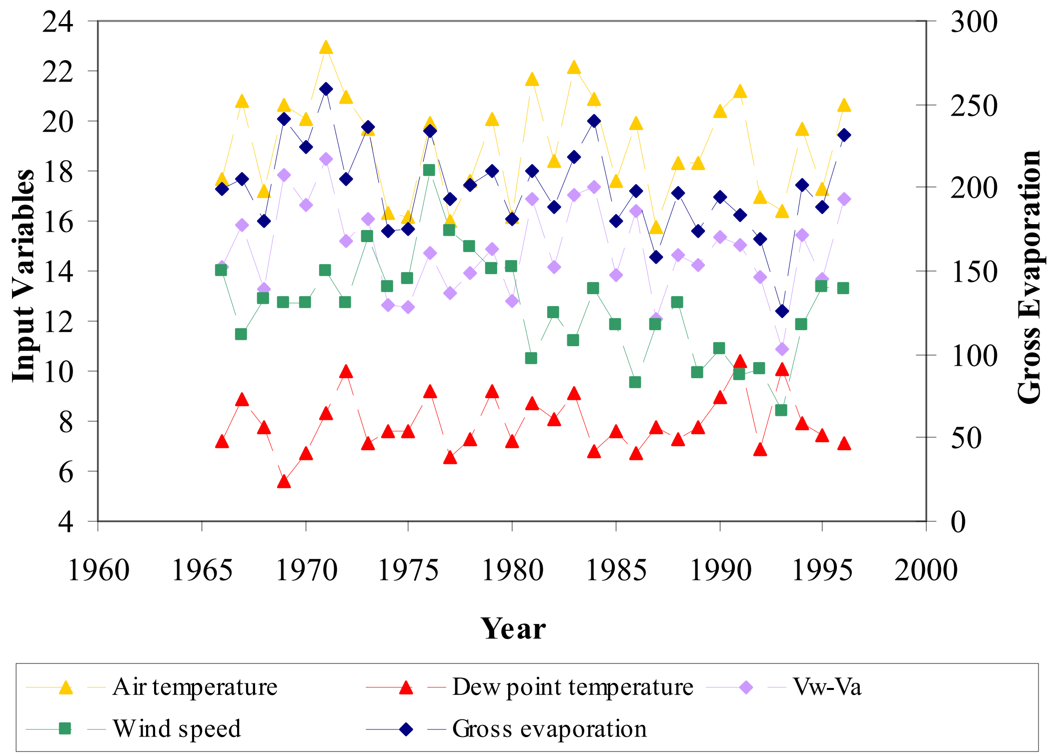

Figure J2: Time-series plot of gross evaporation and input variables at Altawan/Medicine Hat in August

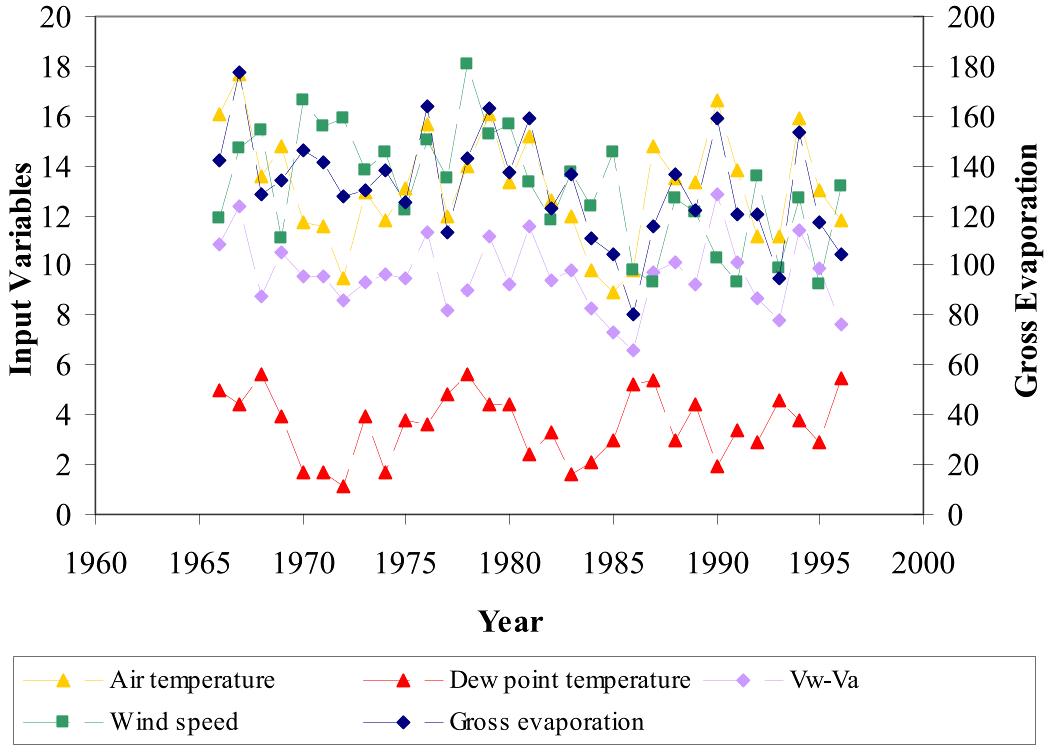

Figure J3: Time-series plot of gross evaporation and input variables at Altawan/Medicine Hat in September

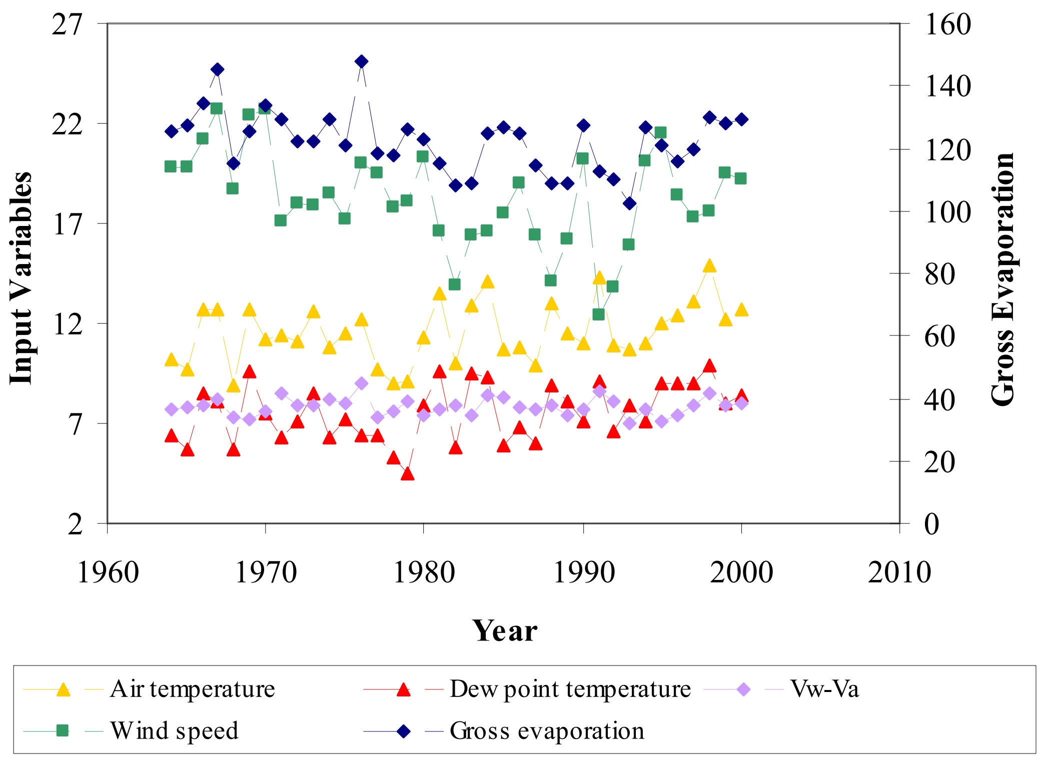

Figure J4: Time-series plot of gross evaporation and input variables at Churchill in August

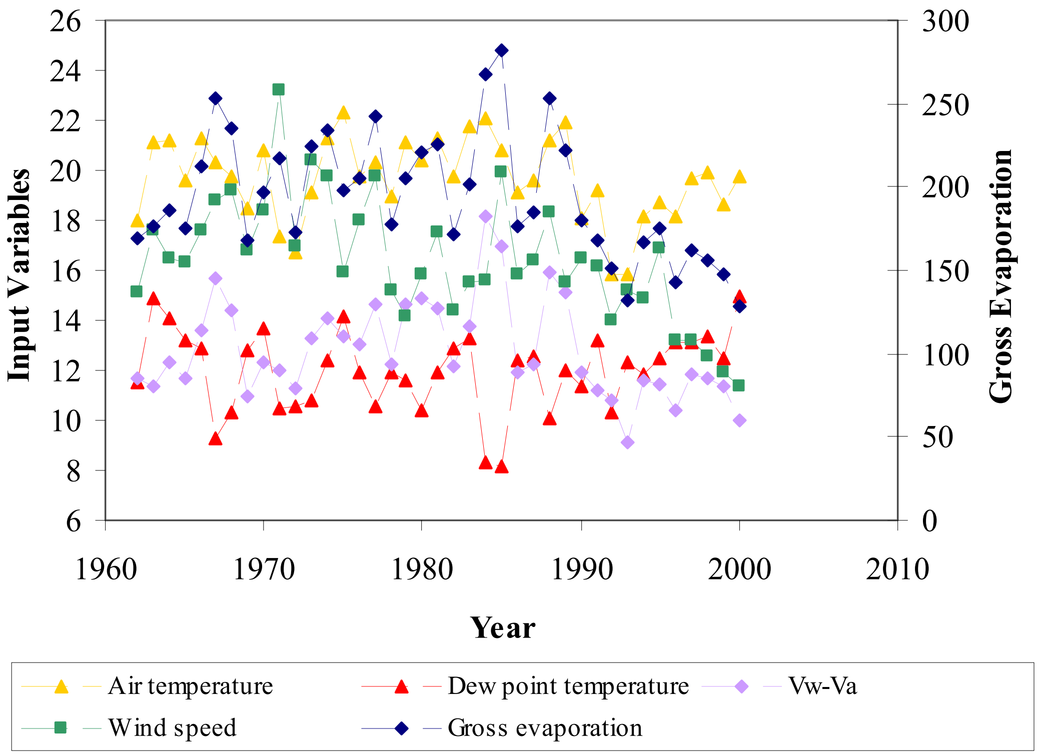

Figure J5: Time-series plot of gross evaporation and input variables at Estevan in July

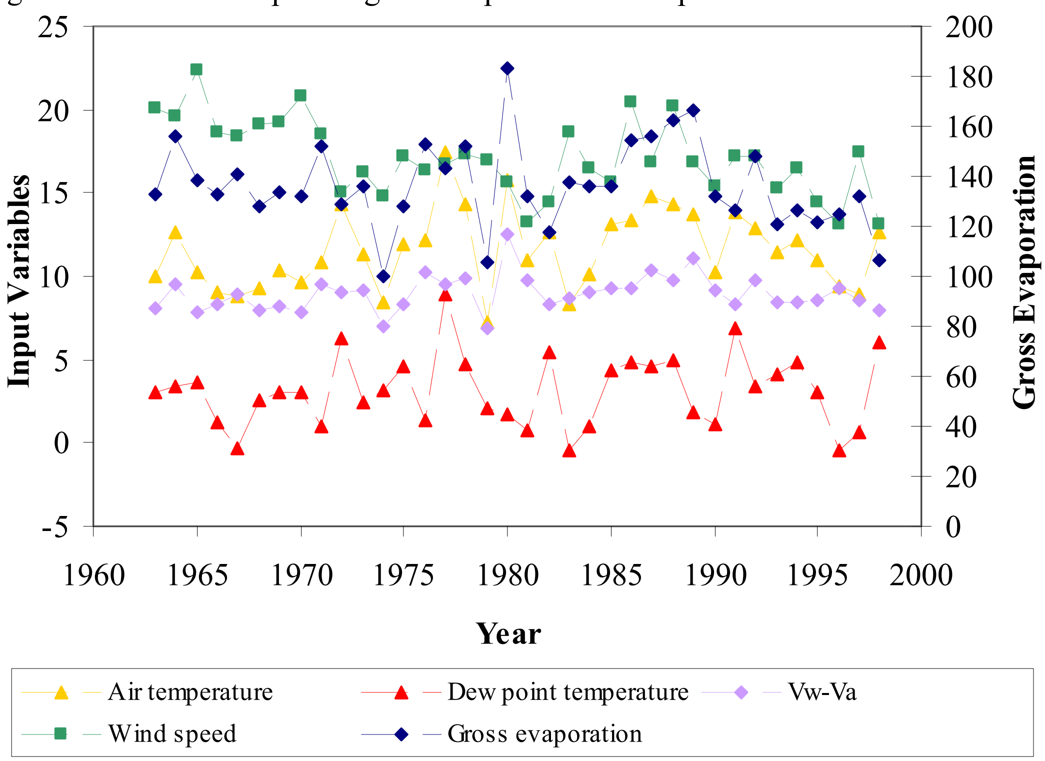

Figure J6: Time-series plot of gross evaporation and input variables at Morden/Portage La Prairie in May

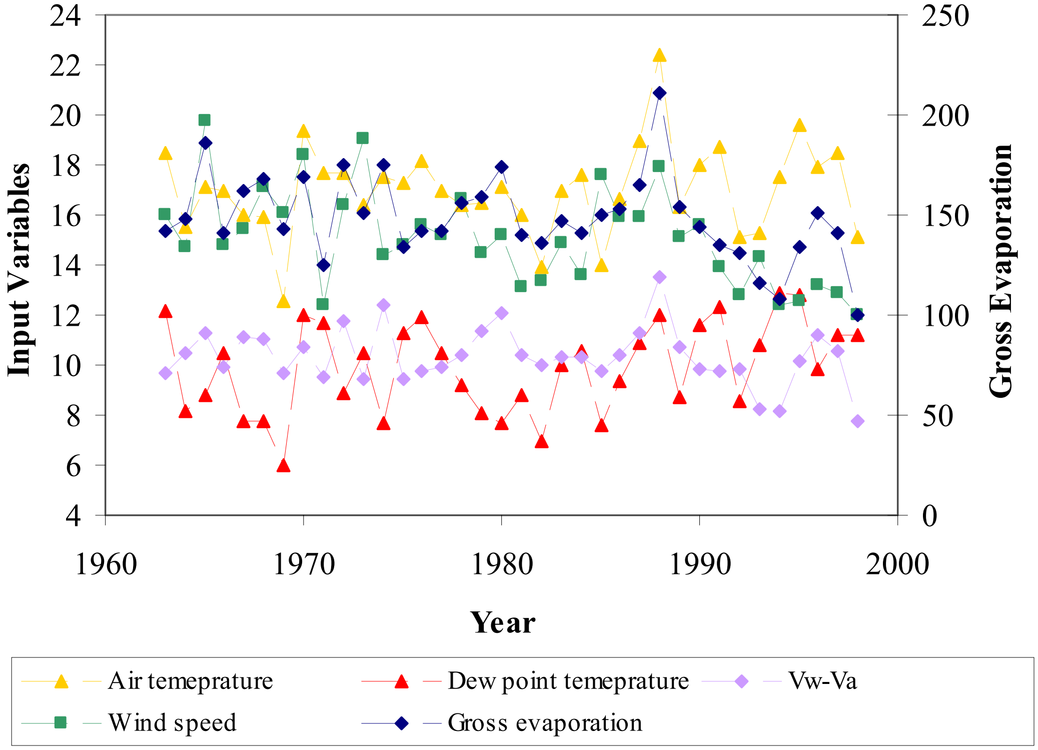

Figure J7: Time-series plot of gross evaporation and input variables at Morden/Portage La Prairie in June

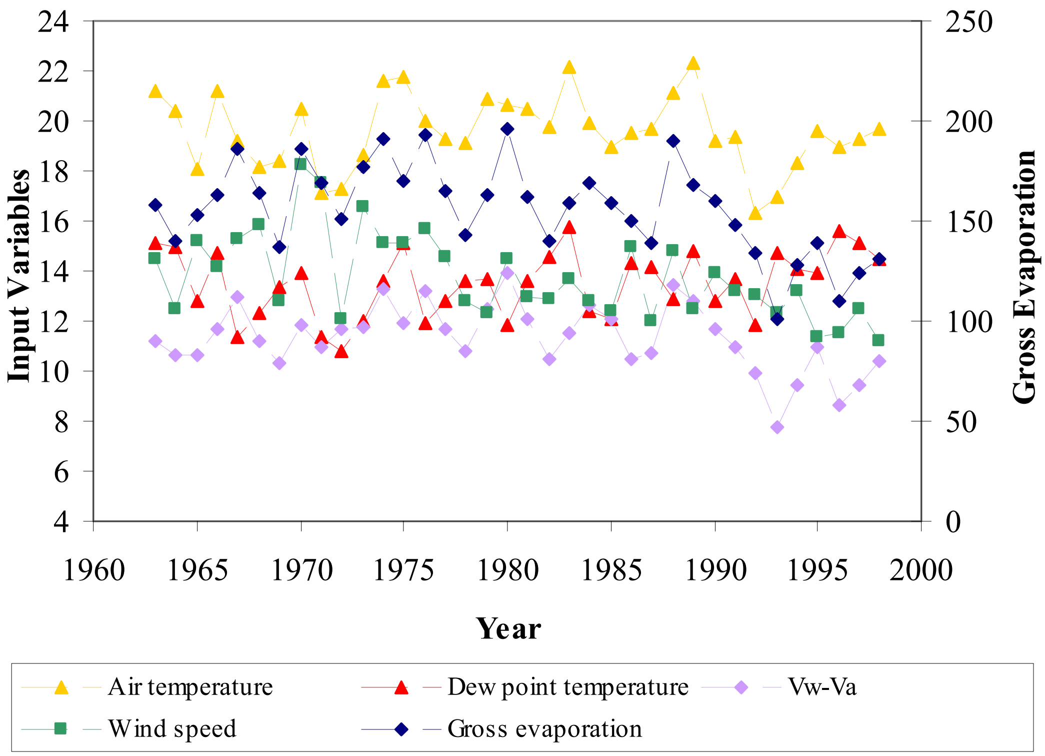

Figure J8: Time-series plot of gross evaporation and input variables at Morden/Portage La Prairie in July

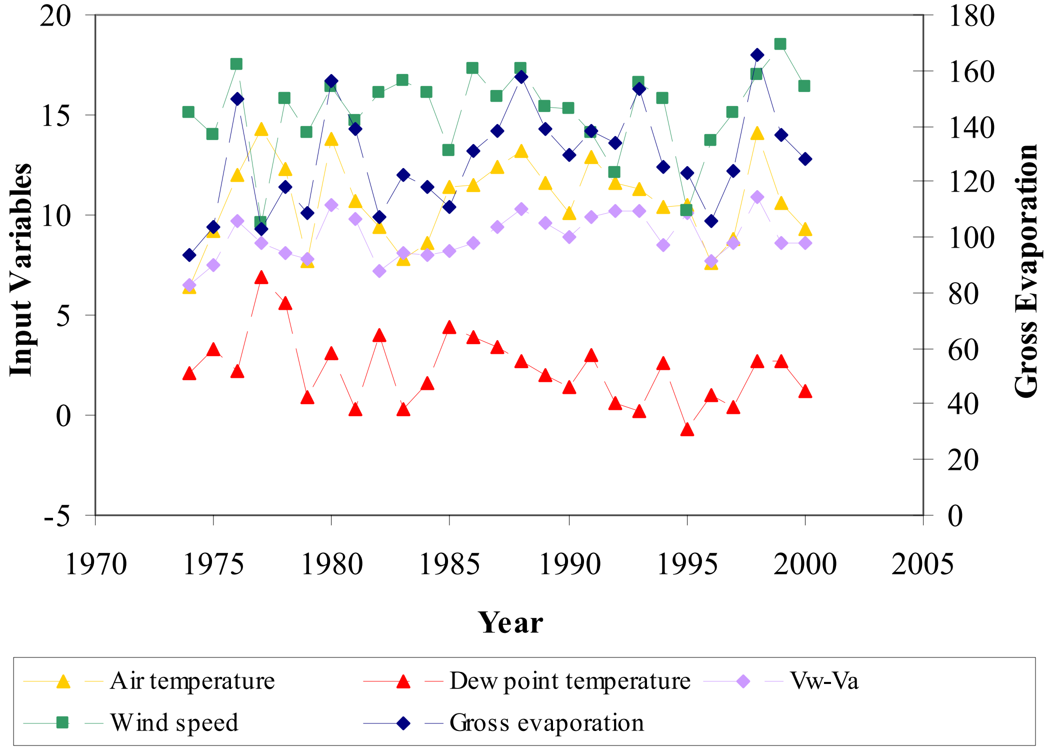

Figure J9: Time-series plot of gross evaporation and input variables at Nipawin in May

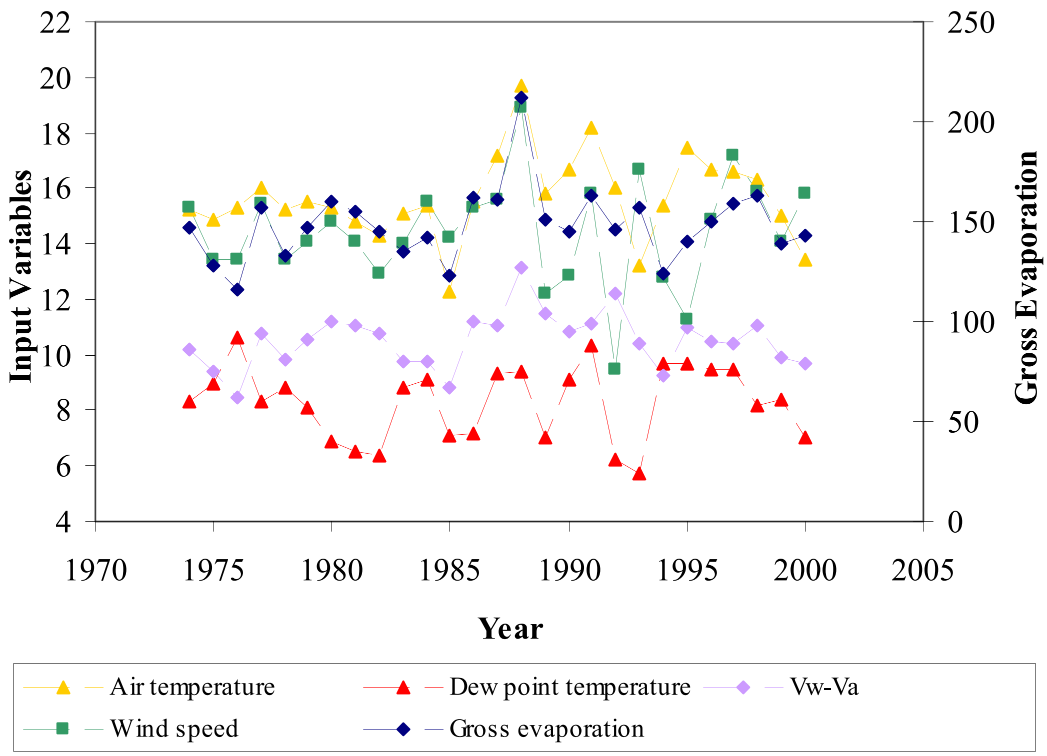

Figure J10: Time-series plot of gross evaporation and input variables at Nipawin in June

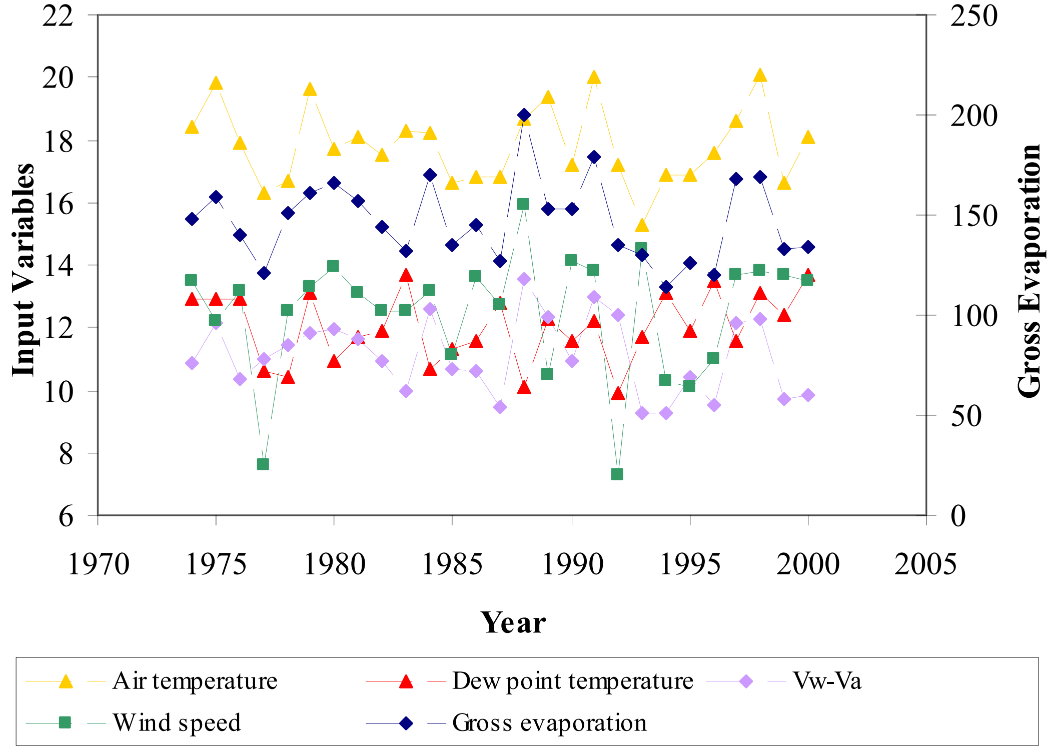

Figure J11: Time-series plot of gross evaporation and input variables at Nipawin in July

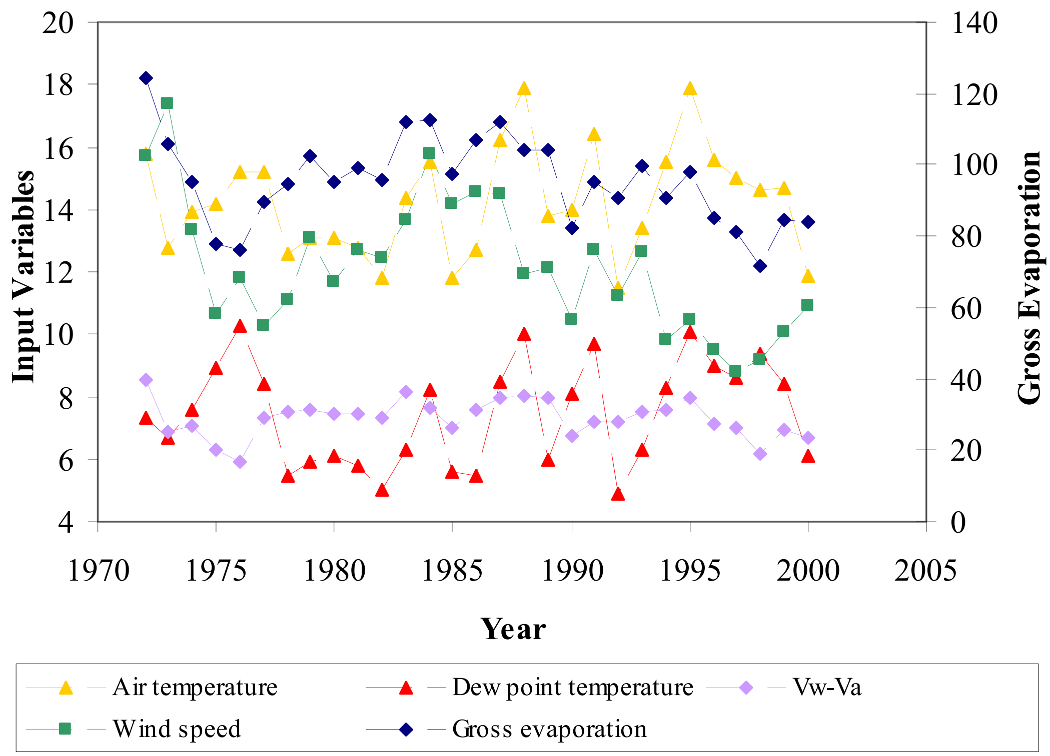

Figure J12: Time-series plot of gross evaporation and input variables at Norway House in June

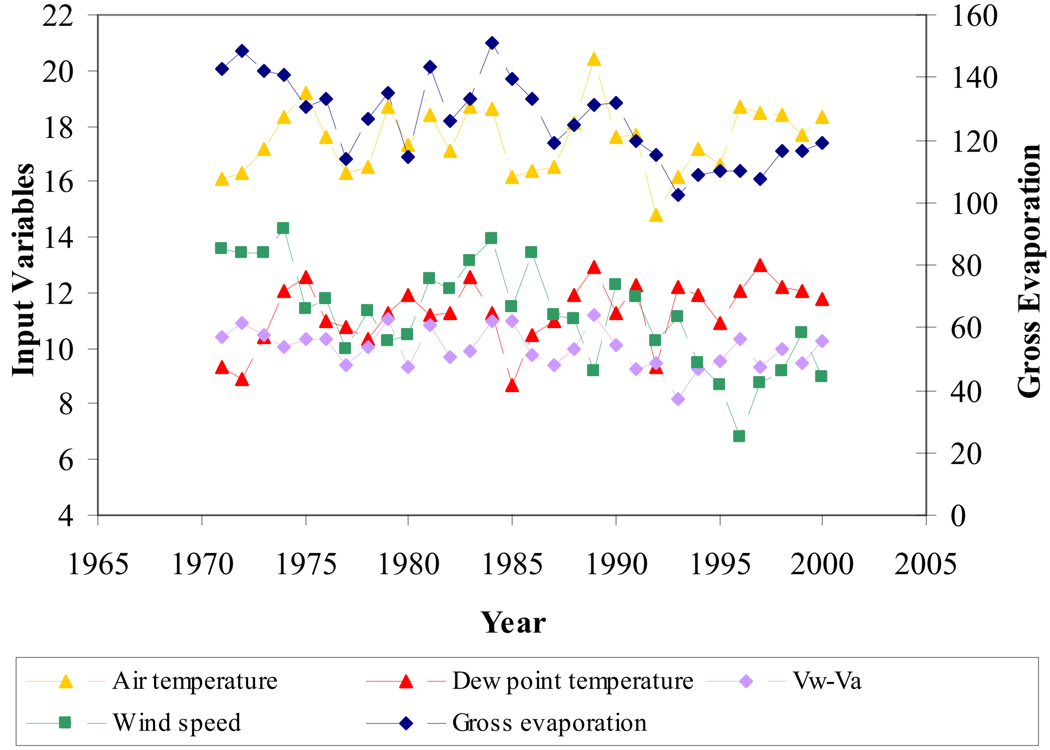

Figure J13: Time-series plot of gross evaporation and input variables at Norway House in July

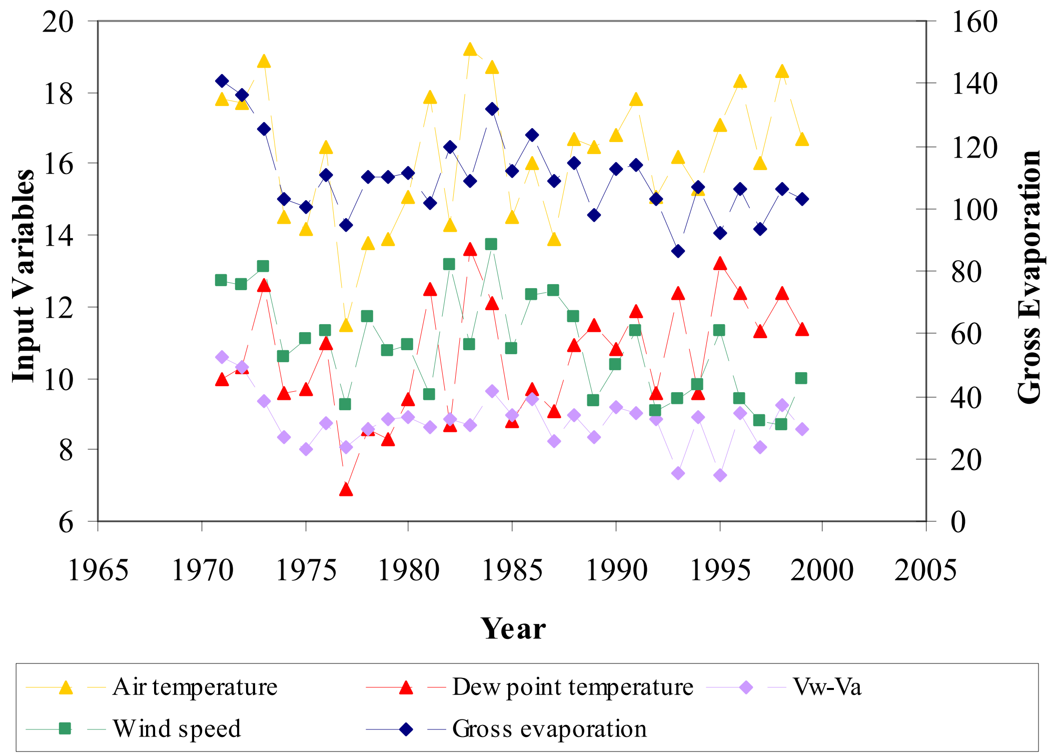

Figure J14: Time-series plot of gross evaporation and input variables at Norway House in August

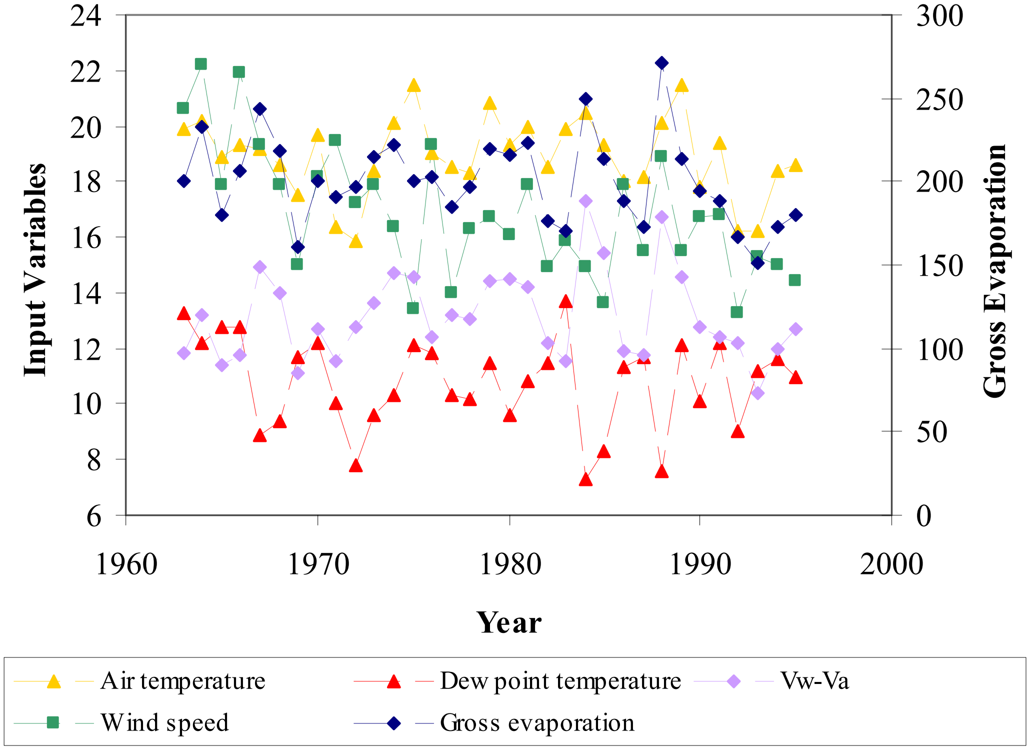

Figure J15: Time-series plot of gross evaporation and input variables at Regina in July

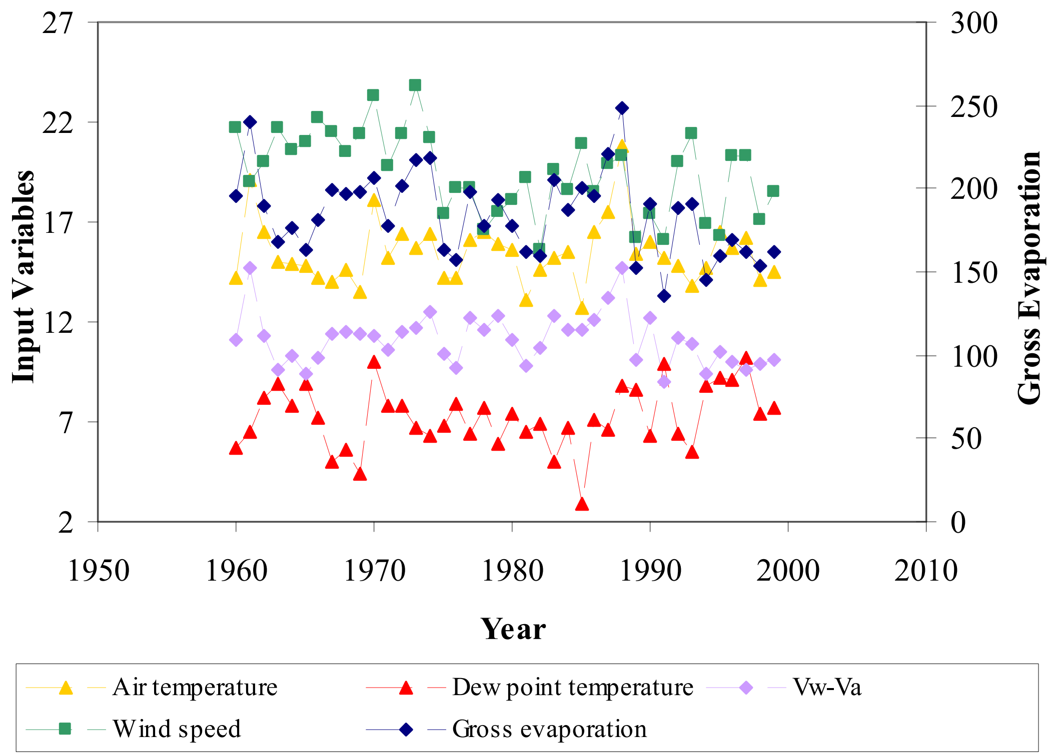

Figure J16: Time-series plot of gross evaporation and input variables at Swift Current in June

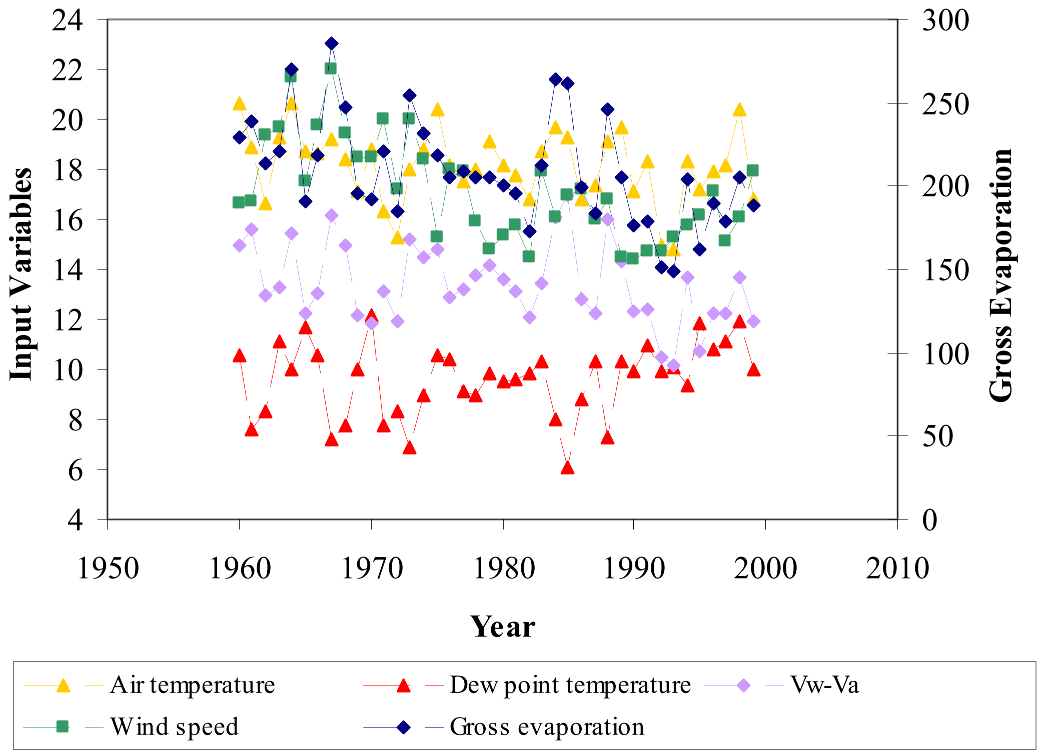

Figure J17: Time-series plot of gross evaporation and input variables at Swift Current in July

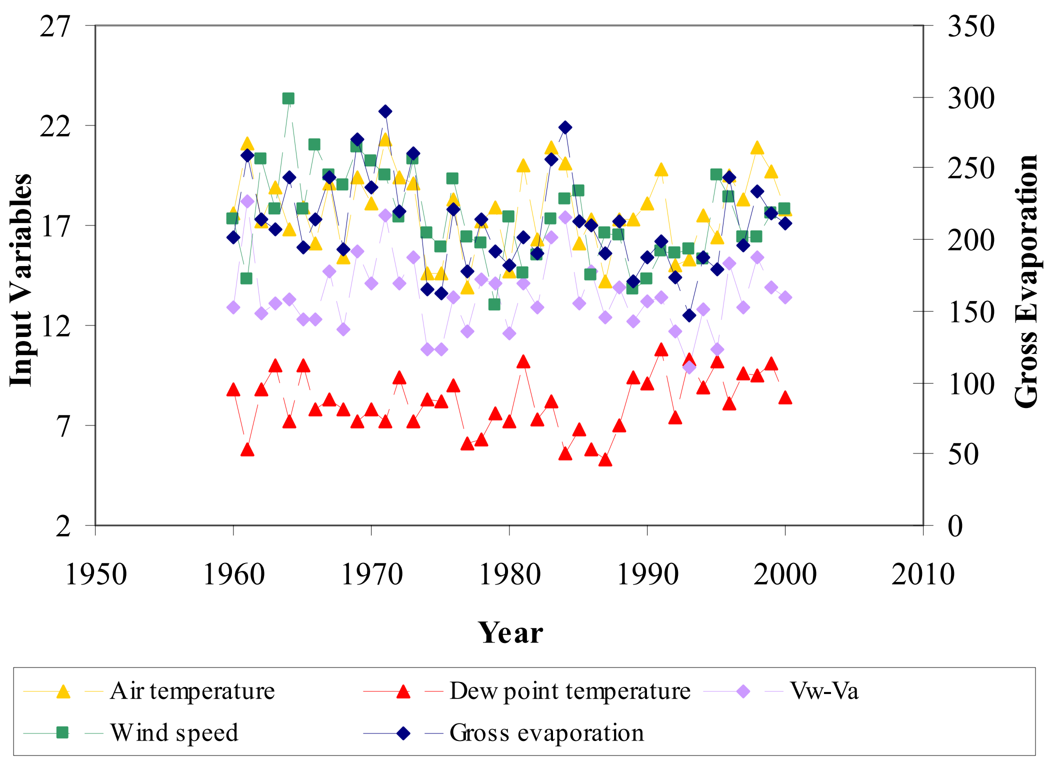

Figure J18: Time-series plot of gross evaporation and input variables at Swift Current in August

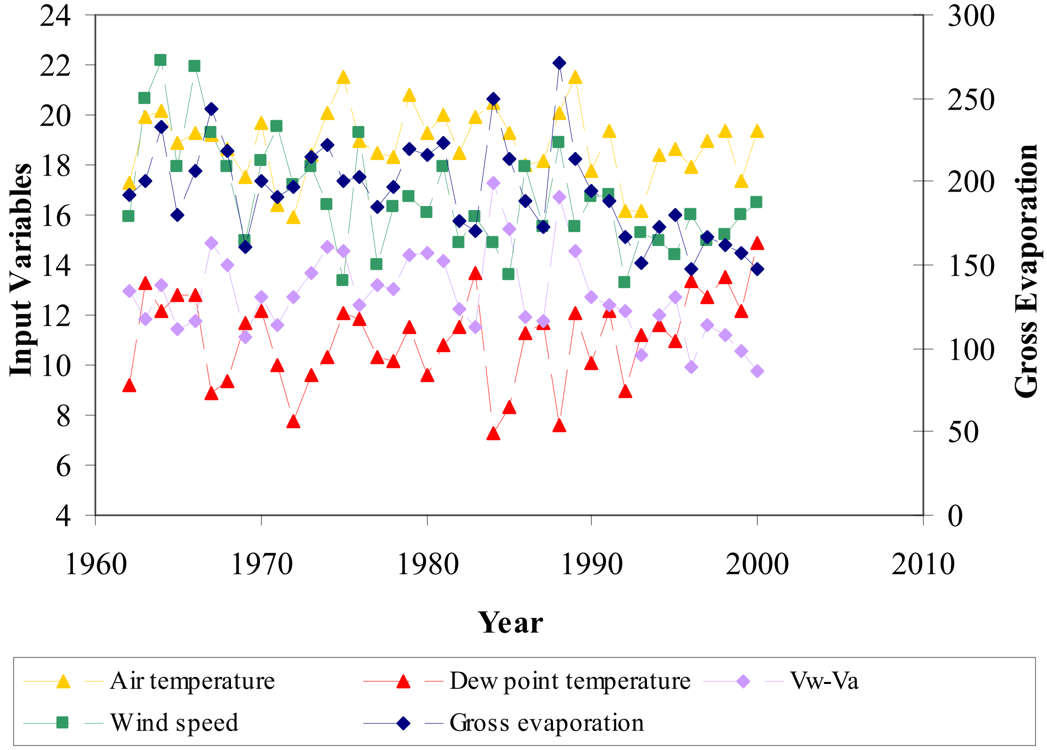

Figure J19: Time-series plot of gross evaporation and input variables at Weyburn/Regina in July

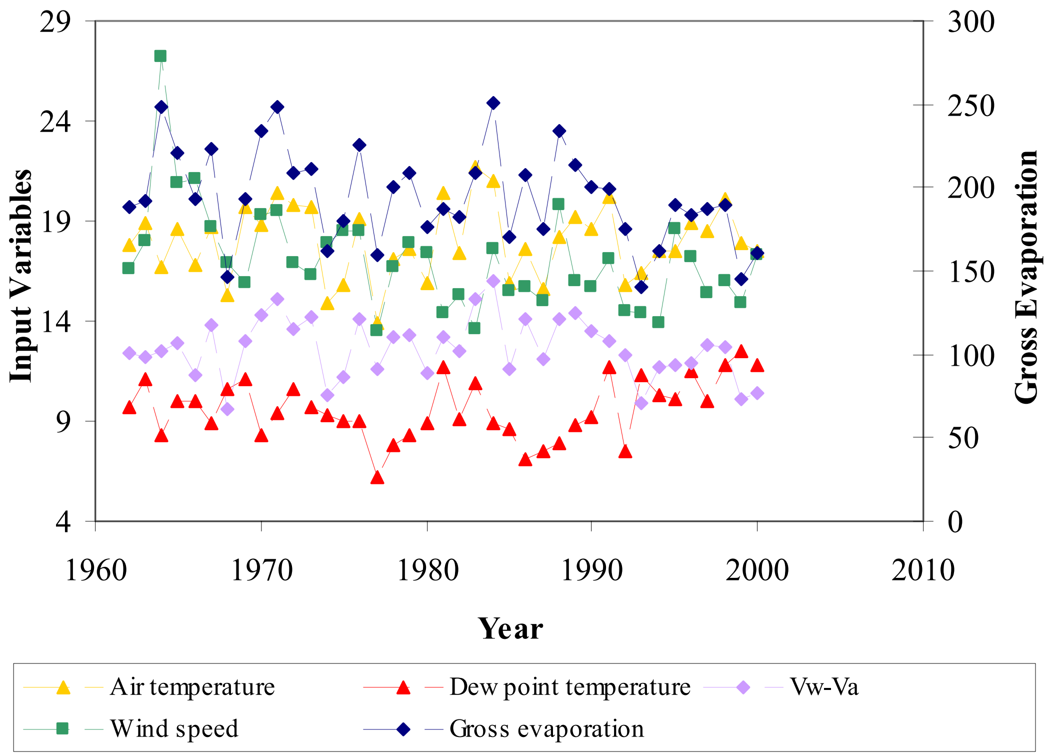

Figure J20: Time-series plot of gross evaporation and input variables at Weyburn/Regina in August

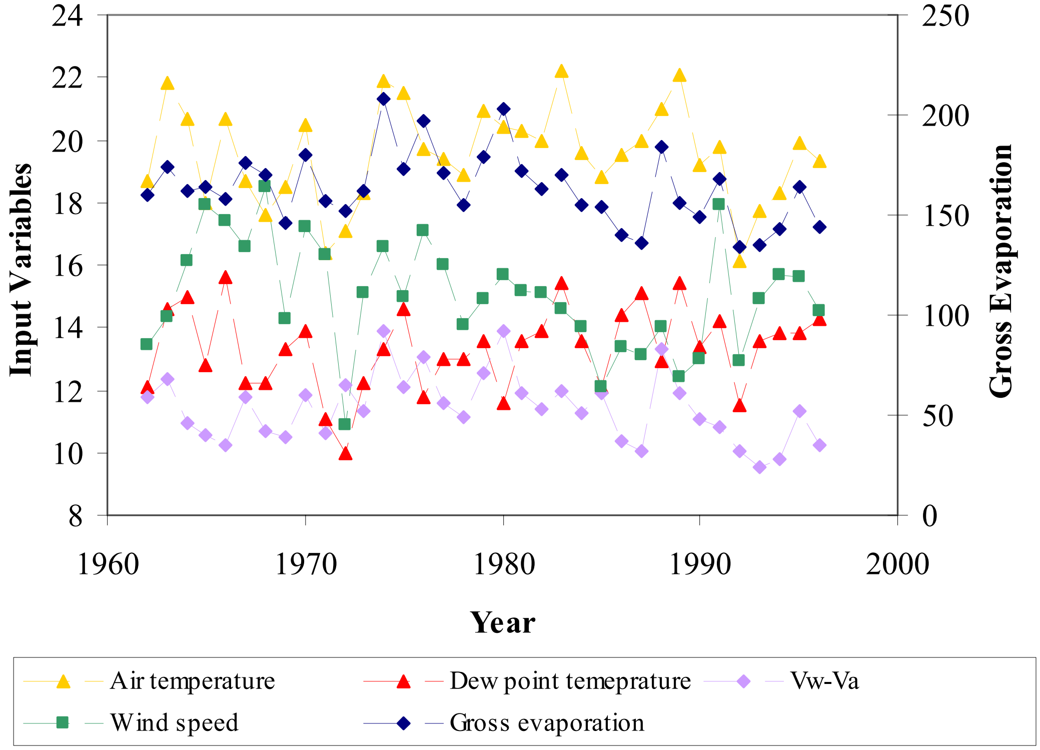

Figure J21: Time-series plot of gross evaporation and input variables at Winnipeg in July

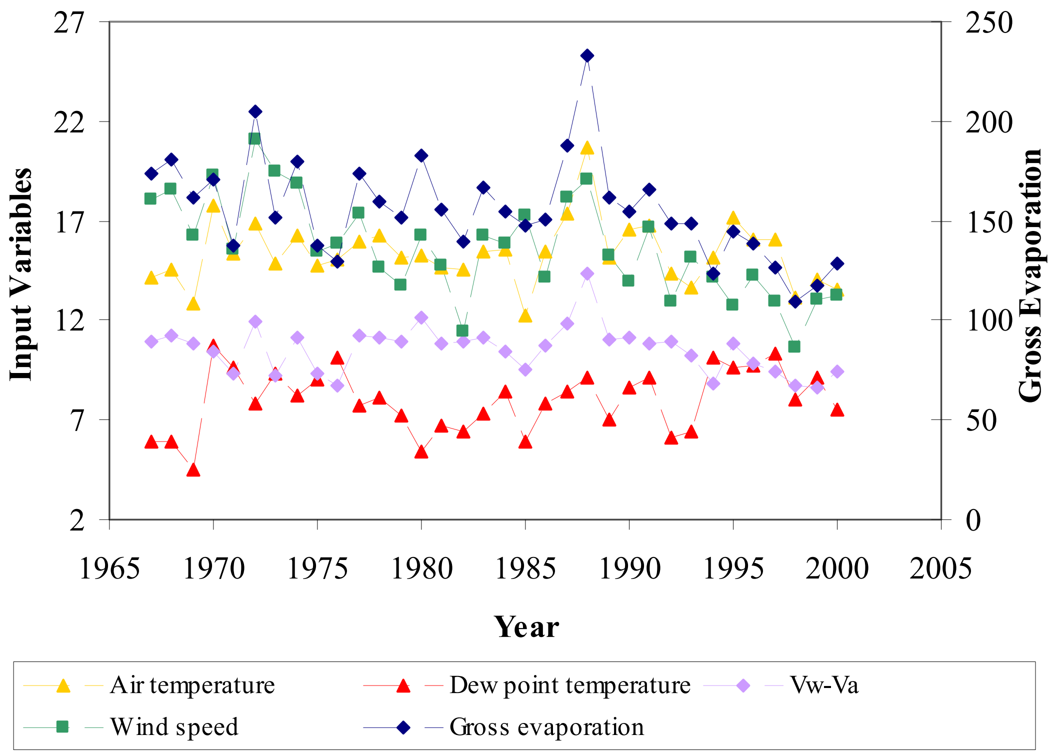

Figure J22: Time-series plot of gross evaporation and input variables at Wynyard in June

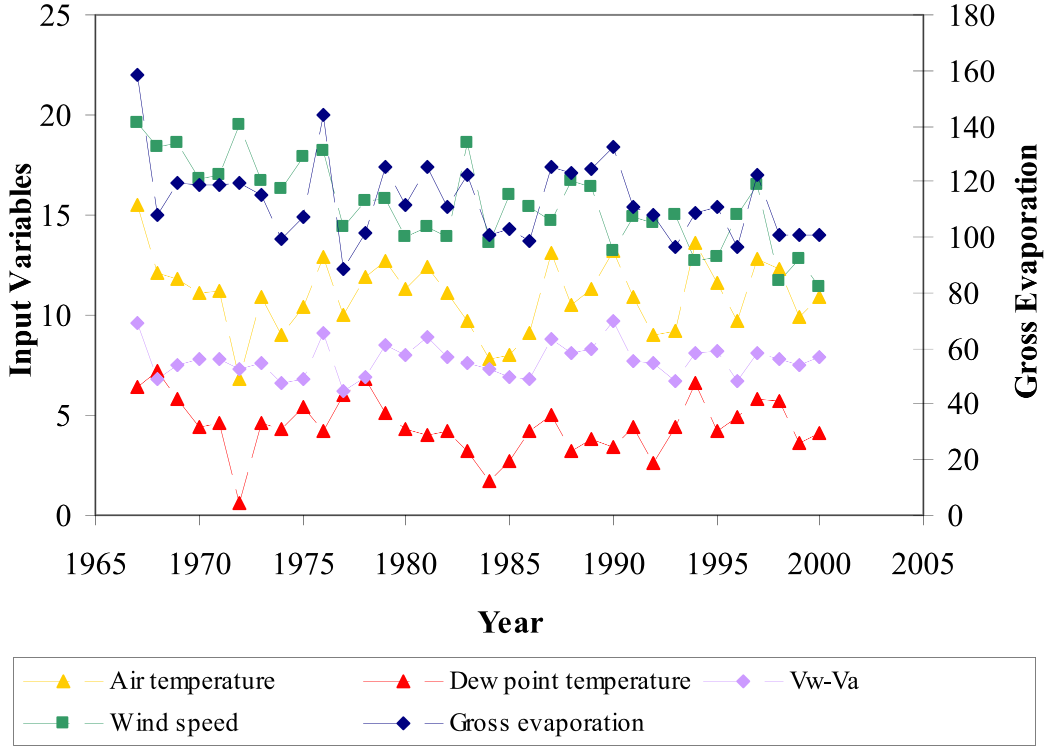

Figure J23: Time-series plot of gross evaporation and input variables at Wynyard in September

Appendix K

Correlations between Gross Evaporation and Input Variables

Table K1: Correlations between gross evaporation and input variables at Altawan/Medicine Hat

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	0.6887	0.6346	0.6799	0.7477	0.7572
Dew point temperature	-0.5920	-0.3802	-0.6581	-0.2249	-0.2240
Water vapour pressure	0.6930	0.6347	0.6732	0.7462	0.7624
Air vapour pressure	-0.5913	-0.3882	-0.6534	-0.2311	-0.2271
V_w-V_a	0.8931	0.9071	0.8945	0.8783	0.8866
Wind speed	0.6109	0.7880	0.7487	0.5015	0.4503

Table K2: Correlations between gross evaporation and input variables at Calgary Intl A/Calgary

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	--	0.7051	0.6609	0.5961	0.6797
Dew point temperature	--	-0.2512	-0.6852	-0.4827	-0.1533
Water vapour pressure	--	0.7083	0.6601	0.5987	0.6835
Air vapour pressure	--	-0.2595	-0.6774	-0.4708	-0.1498
V_w-V_a	--	0.9325	0.9546	0.9231	0.9176
Wind speed	--	0.6862	0.4353	0.4178	0.0171

Table K3: Correlations between gross evaporation and input variables at Churchill/Churchill

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	--	--	0.5483	0.1352	--
Dew point temperature	--	--	0.3067	-0.0967	--
Water vapour pressure	--	--	0.5483	0.1312	--
Air vapour pressure	--	--	0.2987	-0.0990	--
V_w-V_a	--	--	0.7409	0.5157	--
Wind speed	--	--	0.8490	0.7164	--

Table K4: Correlations between gross evaporation and input variables at Estevan A/Estevan

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	0.5906	0.6599	0.5913	0.5479	0.5461
Dew point temperature	-0.3817	-0.3198	-0.6656	-0.3893	-0.1678
Water vapour pressure	0.5933	0.6805	0.5935	0.5579	0.5465
Air vapour pressure	-0.3792	-0.3374	-0.6515	-0.3979	-0.1877
V_w-V_a	0.9197	0.9520	0.9403	0.8652	0.8602
Wind speed	0.3849	0.5795	0.6908	0.4934	0.4587

Table K5: Correlations between gross evaporation and input variables at Morden CDA/Portage La Prairie

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	0.5472	0.3833	0.4620	0.3889	0.3602
Dew point temperature	-0.0978	-0.3048	-0.4722	-0.4749	-0.3499
Water vapour pressure	0.5457	0.3968	0.4620	0.3887	0.3623
Air vapour pressure	-0.1014	-0.3190	-0.4807	-0.4837	-0.3710
V_w-V_a	0.8699	0.9222	0.9364	0.9347	0.9256
Wind speed	0.3625	0.7009	0.6752	0.6074	0.6487

Table K6: Correlations between gross evaporation and input variables at Nipawin A/Nipawin

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	0.6438	0.6204	0.6645	0.7842	0.5120
Dew point temperature	-0.1799	-0.0769	-0.3171	0.1870	-0.3053
Water vapour pressure	0.6369	0.6353	0.6648	0.7927	0.5118
Air vapour pressure	-0.2019	-0.0849	-0.3181	0.1816	-0.3075
V_w-V_a	0.8876	0.8436	0.8668	0.8916	0.8786
Wind speed	0.4946	0.6304	0.6024	0.5510	0.6737

Table K7: Correlations between gross evaporation and input variables at Norway House Forestry/Norway House

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	--	0.0973	0.1422	0.3443	0.0264
Dew point temperature	--	-0.3373	-0.4184	-0.0930	-0.4036
Water vapour pressure	--	0.1030	0.1424	0.3469	0.0304
Air vapour pressure	--	-0.3466	-0.4204	-0.1115	-0.4115
V_w-V_a	--	0.8517	0.7907	0.9207	0.8043
Wind speed	--	0.8026	0.7694	0.7738	0.7136

Table K8: Correlations between gross evaporation and input variables at Regina A/Regina

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	0.5358	0.6507	0.5750	0.6501	0.5388
Dew point temperature	-0.4200	-0.1443	-0.4807	-0.1488	-0.1664
Water vapour pressure	0.5314	0.6679	0.5746	0.6437	0.5443
Air vapour pressure	-0.4096	-0.1686	-0.4665	-0.1687	-0.1570
V_w-V_a	0.8032	0.8314	0.8635	0.8454	0.8376
Wind speed	0.5863	0.4577	0.4134	0.5943	0.4938

Table K9: Correlations between gross evaporation and input variables at Swift Current CDA/Swift Current

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	0.6616	0.5580	0.6371	0.7478	0.7781
Dew point temperature	-0.5453	-0.4281	-0.6140	-0.3340	0.0334
Water vapour pressure	0.6630	0.5708	0.6358	0.7513	0.7813
Air vapour pressure	-0.5465	-0.4396	-0.5989	-0.3385	0.0316
V_w-V_a	0.9150	0.9158	0.9291	0.9062	0.9038
Wind speed	0.5721	0.5301	0.6214	0.5000	0.3067

Table K10: Correlations between gross evaporation and input variables at Weyburn/Regina

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	0.5659	0.6500	0.5108	0.5834	0.5580
Dew point temperature	-0.4690	-0.2664	-0.6005	-0.2967	-0.1508
Water vapour pressure	0.5623	0.6633	0.5132	0.5806	0.5641
Air vapour pressure	-0.4609	-0.2877	-0.5982	-0.3189	-0.1416
V_w-V_a	0.8320	0.8709	0.8997	0.8630	0.8360
Wind speed	0.6065	0.4775	0.4261	0.5834	0.4835

Table K11: Correlations between gross evaporation and input variables at Winnipeg Intl A/Winnipeg

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	0.6002	0.1429	0.5142	0.5216	0.3866
Dew point temperature	0.0677	-0.3441	-0.1362	-0.1618	-0.1956
Water vapour pressure	0.6016	0.1522	0.5144	0.5212	0.3913
Air vapour pressure	0.0844	-0.3423	-0.1498	-0.1564	-0.2190
V_w-V_a	0.8298	0.8537	0.8667	0.8687	0.8613
Wind speed	0.2219	0.6485	0.4842	0.3950	0.6451

Table K12: Correlations between gross evaporation and input variables at Wynyard/Wynyard

Input Variable	May	Jun	Jul	Aug	Sep
Air temperature	0.6817	0.6064	0.5662	0.5659	0.6096
Dew point temperature	-0.1554	-0.2290	-0.5570	-0.2124	-0.0008
Water vapour pressure	0.6814	0.6184	0.5696	0.5713	0.6264
Air vapour pressure	-0.1445	-0.2418	-0.5619	-0.2324	-0.0096
V_w-V_a	0.8885	0.9052	0.9065	0.8901	0.8431
Wind speed	0.6154	0.7675	0.7248	0.6997	0.4942