1.1 SURFACE HUMIDITY AND TEMPERATURE TRENDS IN CANADA FOR 1953-2004

Lucie A. Vincent* and William A. van Wijngaarden**
Climate Research Branch, Meteorological Service of Canada, Toronto

1. INTRODUCTION

Previous studies of climate trends in Canada have shown a significant warming in the west and south accompanying by a cooling in the northeast over 1950-1998, and this pattern was mostly predominant during the winter and spring (Zhang et al., 2000). The total precipitation has increased across the country although a significant decrease was also found in Western Canada during the winter. These results were based on the analyses of homogenized temperature (Vincent and Gullett, 1999) and adjusted precipitation (Mekis and Hogg, 2000) which are special datasets computed from daily observations and adjusted for changes in instruments and observing practices.

In this study, trends in relative humidity, water vapour pressure, temperature and dew point are examined in order to determine if the warming can be associated to a significant change in air moisture. The analysis is based on hourly observations (as opposed to daily observations) which may also contain artificial biases and discontinuities but for causes different from those affecting the daily values. A complete homogeneity evaluation and adjustment of these four climate elements was first performed in attempt to provide a better estimate of the climate trends. The objective of this paper is to present a preliminary assessment of the annual and seasonal trends in relative humidity, water vapour pressure, temperature and dew point for 1953-2004.

2. DATA

Hourly values of relative humidity, temperature and dew point were directly retrieved from the National Climate Data Archive from the Meteorological Service of Canada for 75 climatological stations across Canada and the period 1953-2004. Hourly observations began at the airports in the late 1940s and early 1950s but they have been accumulated in digital form only from 1953. The water vapour pressure was calculated from the hourly temperature, relative humidity and station pressure. At each station, the daily average was calculated if at least eight hourly values were present in the day. This is due to the frequency of the observations in the early 1950s when observations were taken only every three hours at some of the northern stations. The monthly values are the averages of the daily values when less than 8 days are missing during the month and the seasonal and annual values were computed if all months were present.

3. HOMOGENEITY

Annual and seasonal values were closely examined for discontinuities due to changes in instruments and observing practices. A technique based on regression models was formerly developed for the identification of steps in annual temperature time series (Vincent, 1998); however, this technique required neighbour stations for the proper assessment of the position and magnitude of the steps. In this study, since the neighbours are rather limited (there are fewer stations with hourly values), a similar technique based on regression models but which does not necessitate neighbours was used instead to provide a preliminary homogeneity assessment of the time series (Wang, 2003).

For temperature, dew point and water vapour pressure, very few steps were identified; some could have been associated to a very warm or cold year, others to change in instruments. Consequently, no adjustments were performed for these three climate elements. However for relative humidity, a significant step was frequently detected near the date of the introduction of the dewcel. Past study of the discontinuities in relative humidity in Canada has shown that the replacement of the psychrometer by the dewcel has created an artificial decreasing step in relative humidity mainly at stations located in the north and during the winter time (Van Wijngaarden and Vincent, 2005). Most dewcels were installed in 1971 and 1972, but some installations were also done in the 1980s and 1990s. A second small increasing step was detected in the beginning of the 1990s at a few stations with the date corresponding to a change in the observing agency.

Corresponding authors address: *Lucie Vincent, Climate Research Branch, Meteorological Service of Canada, 4905 Dufferin St., Toronto, Ontario, M3H 5T4; email: Lucie.Vincent@ec.gc.ca

**William Van Wijngaarden, Physics Dept. York University, 4700 Keele St., Toronto, Ontario, M3J 1P3; email: wlaser@yorku.ca

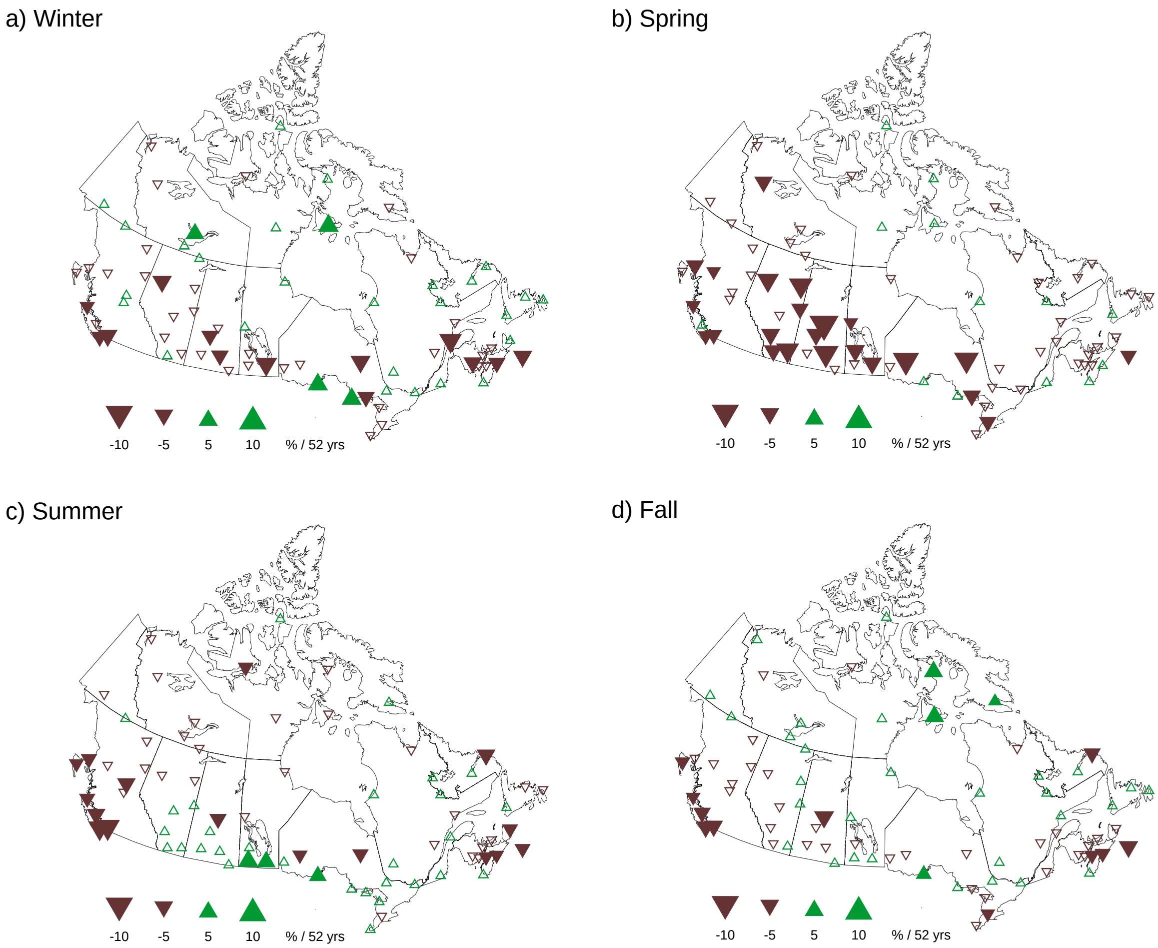

Figure 1. Trends in seasonal relative humidity for 1953-2004. Upward and downward pointing triangles indicate positive and negative trends, respectively. Filled triangles correspond to trends significant at the 5% level; the size of the filled triangle is proportional to the magnitude of the trends.

Adjustments were applied for the dewcel installation date at 50 stations and for the change in agency at eight stations. Annual and seasonal adjustments were derived using a procedure applied in the past for adjusting monthly temperatures (Vincent et al. 2002). Since this procedure requires a reference series, a neighbour (or “far neighbour” in the north) was selected with a dewcel installation date different from the one of the tested site. In addition, periods for computing the adjustments were chosen such as a potential discontinuity of a neighbour would not interfere with the discontinuity of the tested site. Overall, the magnitude of the adjustments prepared for both problems were larger in the winter than the summer.

4. TRENDS AND VARIATIONS

The best-fit linear trend was applied to the annual and seasonal time series to provide an estimate of the linear change. The statistical significance was assessed at the 5% confidence level using the t-test. The results indicate that the most significant changes are found in the relative humidity and temperature. Figure 1 shows the seasonal trends in relative humidity. Significant decreasing trends are observed across southern Canada in winter, and mainly on west and east coasts in summer and fall. However, a strong decrease is found during the spring with some stations showing a negative trend of at least 5% for 1953-2004.

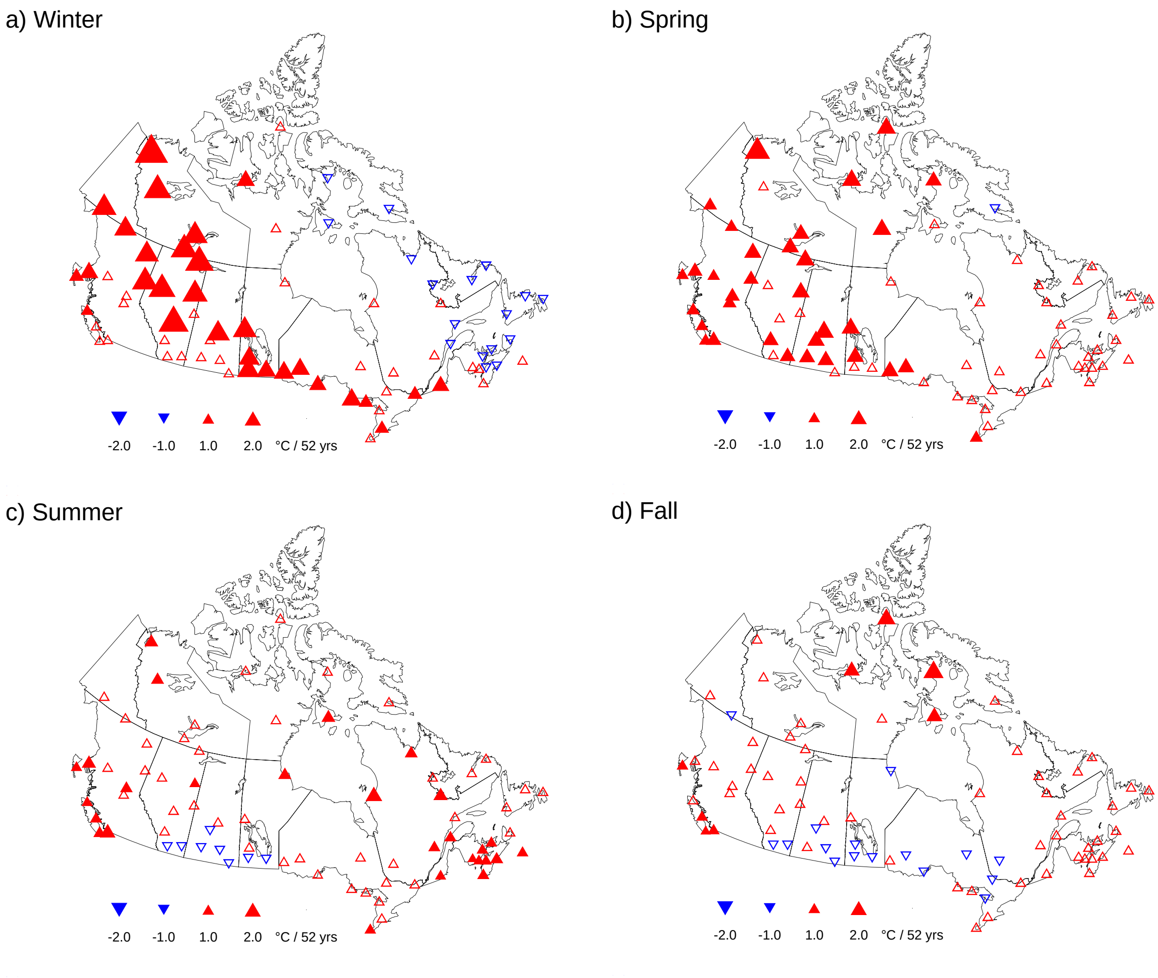

Figure 2. Trends in seasonal temperature for 1953-2004. Upward and downward pointing triangles indicate positive and negative trends, respectively. Filled triangles correspond to trends significant at the 5% level; the size of the filled triangle is proportional to the magnitude of the trends.

An important warming is observed in western Canada (Figure 2) where many stations show an increase at least 2°C over the 52 years in winter and spring. During the summer, smaller significant increasing trends are observed in the north, and west and east coasts, while very few significant trends are found during the fall. For water vapour pressure and dew point, very little changes are observed with the exception of some significant decreasing trends in the northeast during the winter (not presented here). It seems that the significant decrease in relative humidity found in winter and spring in Western Canada is related to significant temperature increase.

Annual and seasonal departures from the 1971-2000 period were obtained at each station and they were averaged together to produce a national time series (Figure 3). Since several stations have considerable missing values in 1953 and 1954, the national series trends are given for 1955-2004. For relative humidity, the original series indicate a decreasing trend of 6.2% over the past 52 years while the adjusted values show a decrease of only 0.8% for the whole country. The artificial decreasing step is also evident from the original series at the beginning of the 1970s. The temperature show a national significant increase of 1.1°C for 1955-2004 while the water vapour pressure and dew point indicate small increase which is not statistically significant.

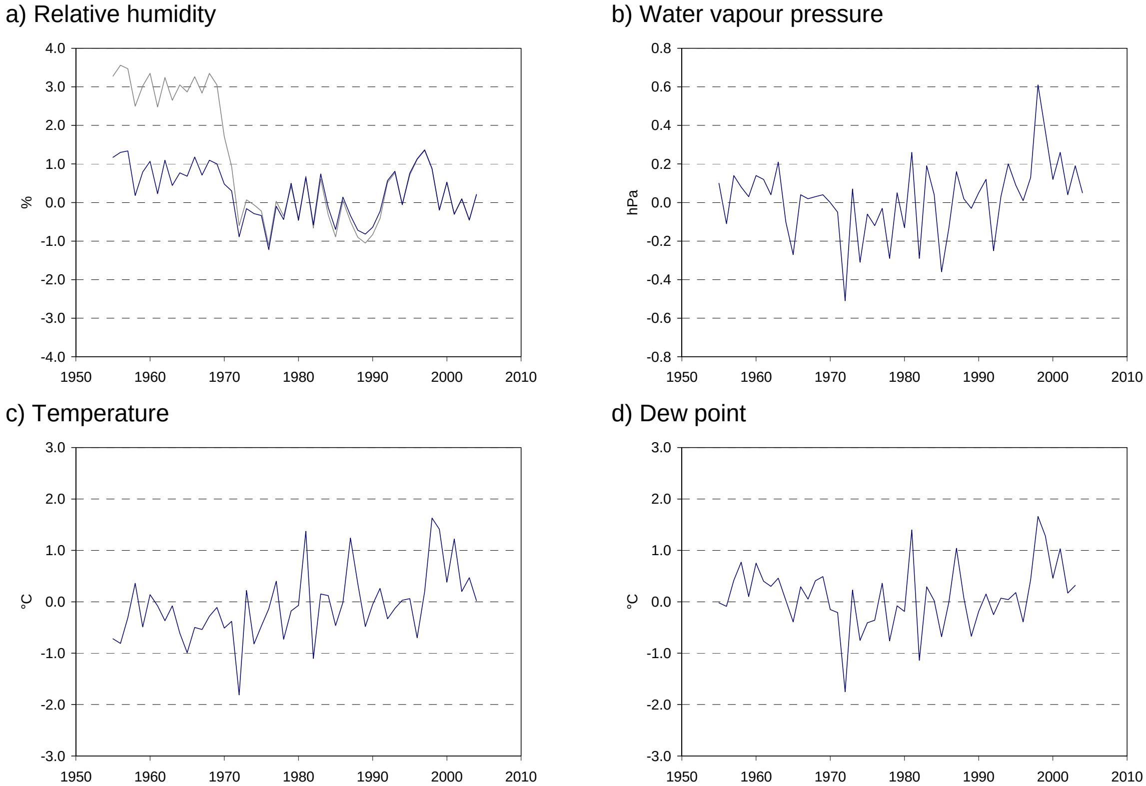

Figure 3. Annual national time series for 1955-2004. The series computed from the original relative humidity (grey) and from the adjusted values (blue) are given in a).

5. CONCLUSION

Preliminary assessment of the trends in relative humidity, water vapour pressure, temperature and dew point indicate that the warming observed in Canada during the past half of the century is not associated with a significant change in air moisture. It seems that the considerable increase in temperature corresponds to significant decrease in relative humidity and there is no evidence for changes in water vapour pressure and dew point. The changes are stronger in western Canada during the winter and spring.

6. REFERENCES

Mekis, É. and W. D. Hogg, 1999: Rehabilitation and analysis of Canadian daily precipitation time series. Atmosphere-Ocean, 37, 53-85.

Vincent, L.A., X. Zhang, B.R. Bonsal and W.D. Hogg, 2002: Homogenization of daily temperatures over Canada. Journal of Climate, 15, 1322-1334.

Vincent, L. A., and D.W. Gullett, 1999: Canadian historical and homogeneous temperature datasets for climate change analyses. International Journal of Climatology, 19, 1375-1388.

Vincent, L. A., 1998: A Technique for the identification of inhomogeneities in Canadian temperature series. Journal of Climate, 11, 1094-1104.

Zhang, X., L.A. Vincent, W.D. Hogg and Ain Niitsoo, 2000: Temperature and precipitation trends in Canada during the 20th Century. Atmosphere and Ocean, 38, 395-429.

Wang, X. L., 2003: Comments on detection of undocumented changepoints: a revision of the two-phase regression model. Journal of Climate, 16, 3383-3385.

Van Wijngaarden, W.A., and L.A. Vincent, 2005: Examination of discontinuities in hourly surface relative humidity in Canada during 1953-2003. Journal of Geophysical Research, accepted.