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TRENDS IN RELATIVE HUMIDITY IN CANADA FROM 1953-2003

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

1. INTRODUCTION

Relatively little work has been done examining archival data of relative humidity searching for evidence of climate change as compared to studying records of temperature and precipitation. Relative humidity is important in its own right as it directly affects atmospheric visibility, strongly influencing the formation of clouds, fog and smog (Elliott and Angell, 1997).

Much of the work on climate trends in Canada has been done on temperature, precipitation and snowcover. Over the last 50 years, there has been a significant warming in the West while Northeastern Canada has cooled (Zhang et al., 2000). Total annual precipitation has increased by 5% across the country (Zhang et al., 2000) while snowcover has decreased (Brown and Braaten, 1998). Careful examination of annual, monthly and daily measurements has enabled the data to be checked for systematic changes in observation techniques/procedures and be adjusted accordingly (Vincent and Gullett, 1999 and Mekis and Hogg, 1999).

The purpose of this project is to assess changes in relative humidity over the period 1953-2003. This study has undertaken the first analysis of *hourly* data recorded at 75 airport stations located throughout Canada. This data set did not include urban centers such as Toronto, Vancouver and Montreal whose metropolitan areas have greatly grown over the last decades possibly creating large urban heat islands. An additional criteria for station selection was that less than 1% of the data be missing for stations located below 60^{o} N latitude while the corresponding amount of missing data for Arctic stations be less than 10%.

*Corresponding author address: William A. van Wijngaarden, Physics Dept., Petrie Bldg., York University, 4700 Keele St., Toronto, ON, Canada, M3J 1P3; e-mail: wlaser@yorku.ca

**Climate Research Branch, Meteorological Service of Canada, Downsview, ON, Canada, M3H 5T5; e-mail: Lucie.Vincent@ec.gc.ca

2. HOURLY MEASUREMENTS OF RELATIVE HUMIDITY

Relative humidity changes significantly on not only a seasonal basis but throughout each day. Generally, it is lowest in the afternoon and highest at night. The average relative humidity was therefore computed for each season as well as for 4 six hour periods of the day (night 0 – 5 am, morning 6 - 11 am, afternoon 0 - 5 pm and evening 6 - 11 pm) to examine possible seasonal and diurnal trends.

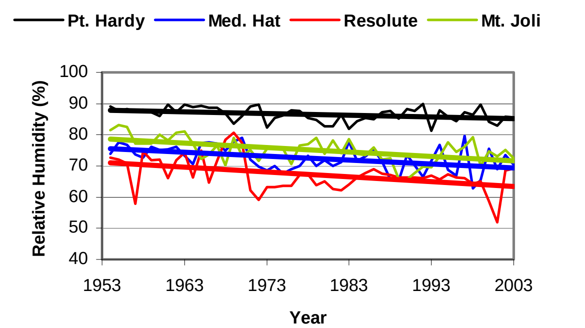

Fig. 1: Trend in Winter Relative Humidity for 4 Stations Located in Different Climate Zones. 1) Port Hardy, British Columbia, 2) Medicine Hat, Alberta 3) Resolute, Nunavut 4) Mont Joli, Quebec.

A linear trendline was computed and fit to the data as shown in Fig. 1 which illustrates the change in average winter relative humidity for four stations located in distinctly different climate zones. Port Hardy is situated on Vancouver Island, B.C., Medicine Hat on the prairies in southern Alberta, Resolute in the northern Arctic and Mt. Joli in Quebec. A statistical t test was performed to determine whether this linear trend was significant at the 5% level. Results are shown in Fig. 2. The data represented in Fig. 2 was averaged over all 24 hours of the day as no discernible difference in relative humidity trends were found for night, morning, afternoon and evening. Figs. 2a and b show a substantial decrease in relative humidity during the winter and spring seasons throughout all Canada. Fewer and weaker trends were evident during the summer and fall.

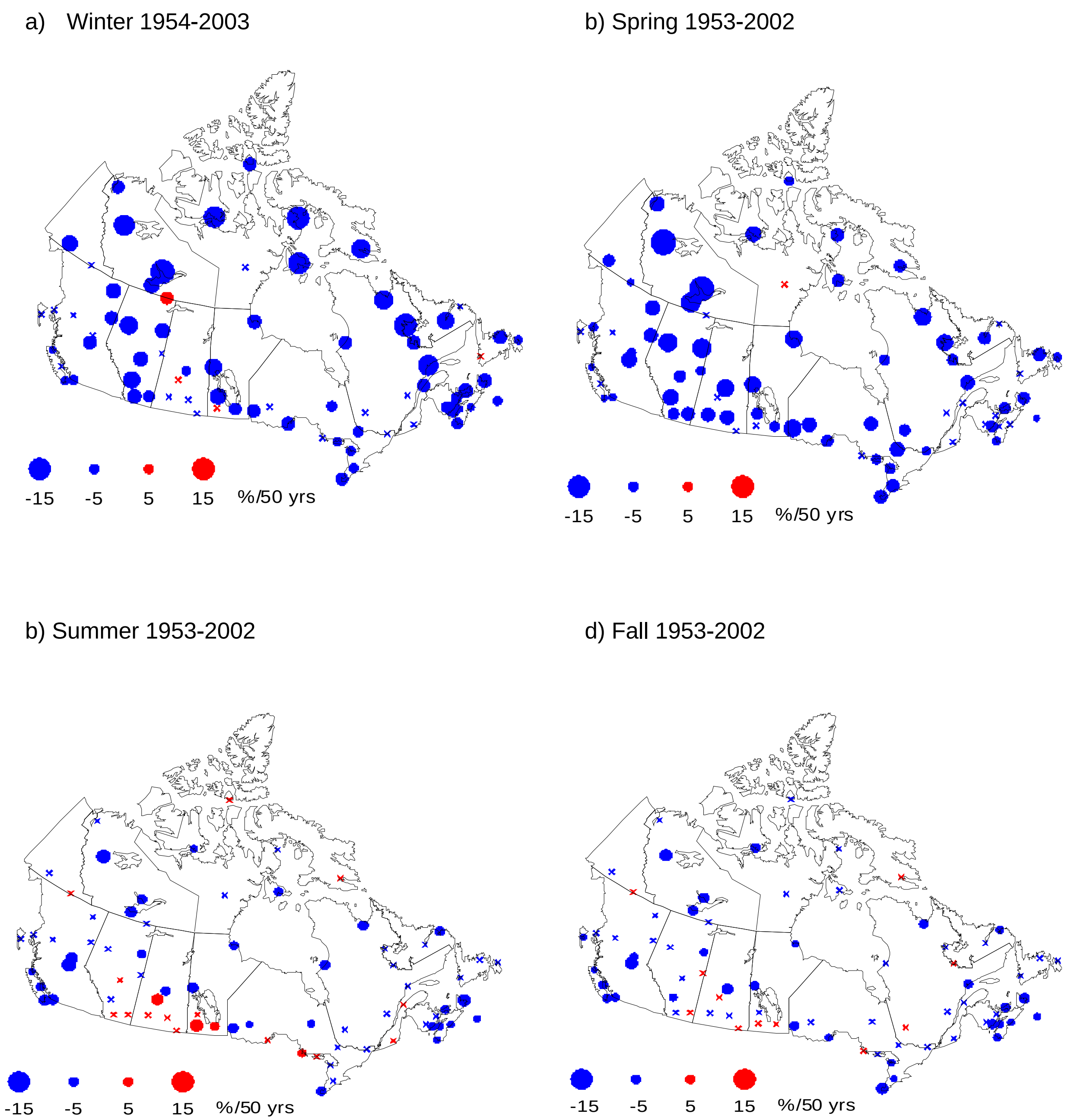

Fig. 2: Trend in Relative Humidity During 1953-2003 a) Winter; b) Spring; c) Summer; d) Fall. Blue (red) dots represent decreasing (increasing) relative humidity statistically significant at the 5% level. Crosses represent insignificant trends.

3. COMPARISON TO HOURLY DEW POINT

Relative humidity is a function of the temperature and absolute water vapour concentration. Hence, a change in relative humidity may be accounted for by a corresponding change in the dew point. Hourly observations of the dew point temperature were analyzed using the same procedure described previously for the relative humidity data and also for the same observation stations. The trends found for the dew point during night, morning, afternoon and evening were all found to be the same. The only statistically significant change in dew point was found for Northeastern Canada in the winter as is shown in Fig. 3.

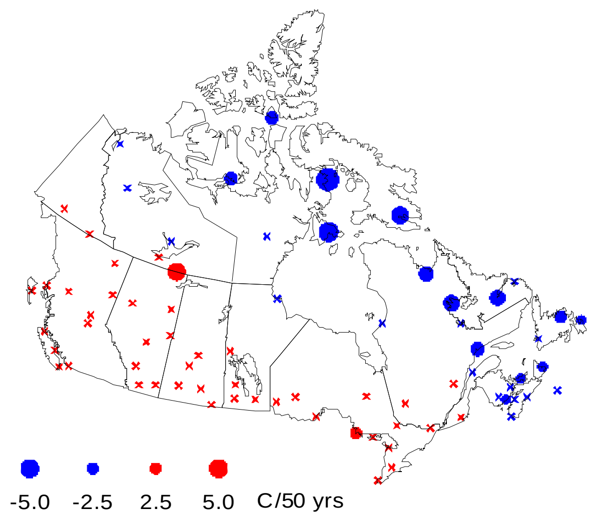

Fig. 3: Trend in Winter Dew Point Temperature during 1954-2003. Blue (red) dots represent decreasing (increasing) dew point statistically significant at the 5% level. Crosses represent insignificant trends.

4. COMPARISON TO HOURLY TEMPERATURE

Hourly temperature measurements were also analyzed for data taken at the 75 stations. Temperature trends during night, morning, afternoon and evening showed no discernible difference. The results reveal a significant temperature increase especially for western Canada and the Arctic in winter and spring as is shown in Fig. 4. The decreasing temperature trends found in Northeastern Canada, although not statistically significant at the 5% level, is consistent with the cooling observed over the North Atlantic during the last 50 years (Zhang et al., 2000). Fewer statistically significant and smaller trends were found in summer and fall temperatures.

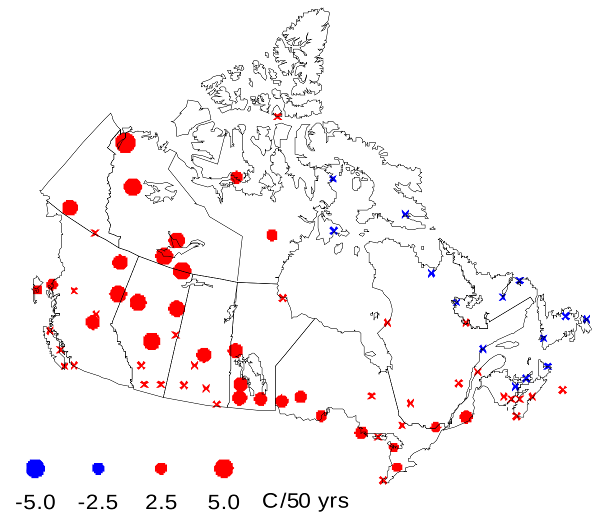

Fig. 4: Trend in Winter Temperature during 1954-2003. Blue (red) dots represent decreasing (increasing) temperature statistically significant at the 5% level. Crosses represent insignificant trends.

5. COMPARISON TO DAILY PRECIPITATION

Daily precipitation data were examined as hourly records of precipitation were unavailable for the time period 1953-2003 for the 75 stations considered in this study. Previous studies have found that precipitation increases across Canada by 5% to 35% for the period 1950-1998 (Mekis and Hogg, 1999) for all seasons except perhaps in winter. In this study, the total precipitation for each season was computed along with the percentage change compared to the average seasonal amount received during 1961-1990. Precipitation does appear to increase slightly for the spring, summer and fall but decreases significantly in the winter. Fig. 5 shows the precipitation decrease is in excess of 50% for many stations in Western Canada.

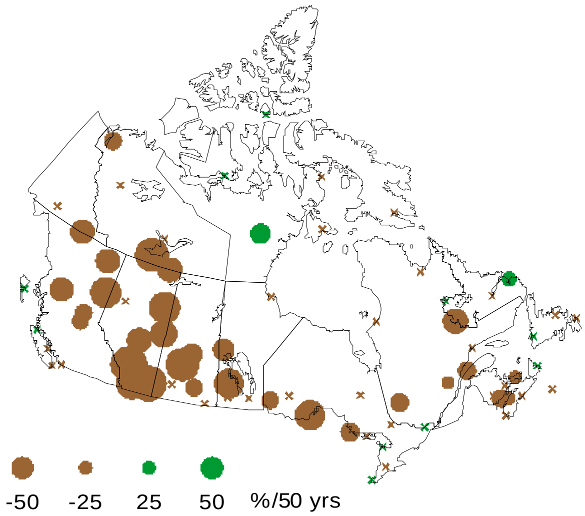

Fig. 5: Trend in Percentage Winter Precipitation Change during 1954-2003 relative to 1961-90. Green (brown) dots represent increasing (decreasing) precipitation statistically significant at the 5% level. Crosses represent insignificant trends.

6. CONCLUSIONS

There has been a substantial decrease in relative humidity throughout Canada during 1953-2003. The trend found by averaging the relative humidity for all 75 stations is a 6% decrease significant at the 5% confidence level for winter and spring. For example, if a station recorded a relative humidity of 66% in 1953, the value in 2003 would be 60%. This trend correlates with changes found in the dew point, temperature and precipitation data. In Northeastern Canada, during the winter, the relative humidity decrease coincides with a decrease in the dew point. For western Canada and the Arctic, there has been an increase in winter temperature along with a very large decrease in precipitation. For spring, the decrease in relative humidity appears to be due to a temperature increase in the West while the reason for the reduction in the Northeast requires additional study. It will be interesting to see whether these trends continue. In addition, the relative humidity data should be further checked to make sure that any trend is not associated with a change in measuring procedure or instruments (Déry and Steiglitz, 2001). In conclusion, it would appear that relative humidity is a useful complementary indicator of climate change.

7. References

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