EXAMINATION OF CANADIAN CLIMATE IMMEDIATELY AFTER SEPT. 11, 2001

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1. INTRODUCTION

More than a century of increase use of fossil fuels is now accepted as the primary cause of climate change (IPPC, 2001, 2007). Detecting anthropogenic effects is complicated by the weather's variability and the difficulty of observing a climate unaffected by human activities. A unique opportunity unfortunately arose after September 11, 2001 when flights over North America were severely restricted for the following 3 days. An earlier study found a significant change in the diurnal temperature range (DTR) for the continental U.S. (Travis et al., 2002). The average DTR for Sept. 11-14 was 1.8 ^{o}C higher than for the adjacent three-day periods. It was suggested that the lack of airplane contrails was in part responsible since contrails act like clouds reflecting sunlight during the day and radiation from the Earth's surface at night thereby reducing the DTR (Travis et al., 2004; DeGrand et al., 2000).

This study examined data observed at 112 stations located throughout Canada. Observations during Sept. 8-17, 2001 were compared to average measurements made during 1977-2004. No inhomogeneities in DTR, nor in the average daily temperature, relative humidity or precipitation were evident. The data for stations located south of 50 ^{o}N latitude were examined separately as more flights traverse this region than northern Canada. No effect was found in that case nor when stations west/east of the Manitoba Ontario border were studied.

2. METHODOLOGY

Meteorological observations in Canada at primarily airport stations are digitally archived by Environment Canada. Hourly measurements are made at each station of temperature and relative humidity while a daily measurement of precipitation is recorded. Less than 1.5% of the

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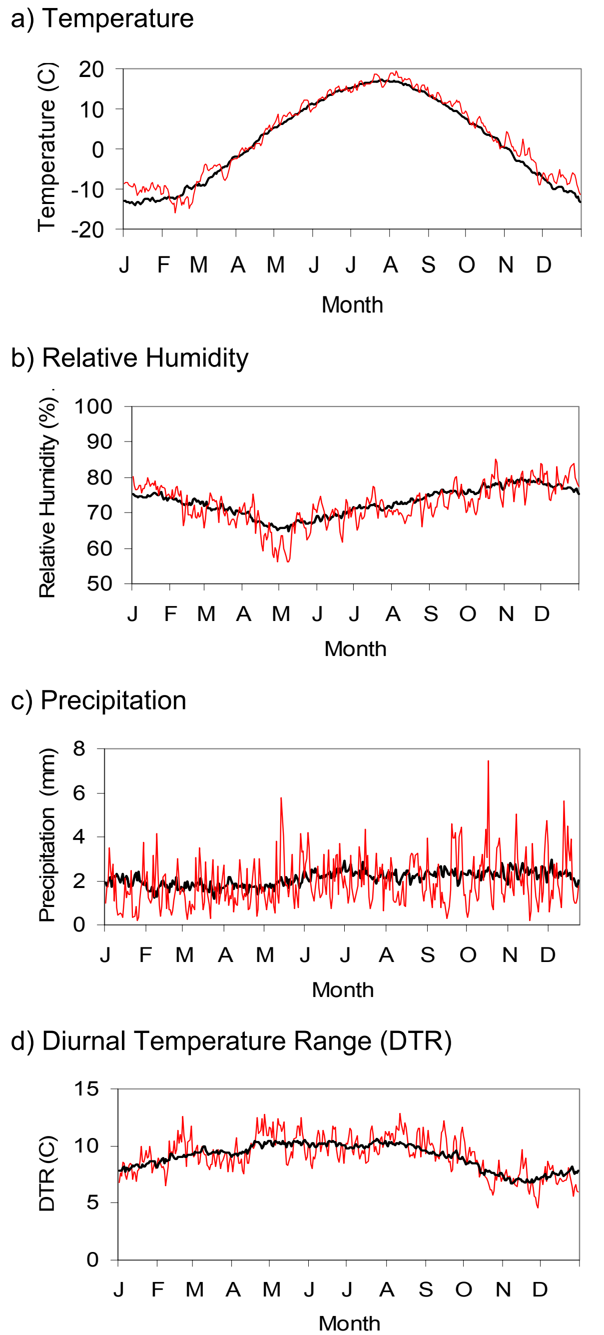

Fig. 1: The daily a) temperature b) relative humidity c) precipitation and d) DTR averaged over all stations as a function of time throughout the year. The black curve represents data averaged for 1977-2005 while the red curve is data for 2001.

data is missing during Jan 1, 1977 to May 4, 2005. This time period was chosen as it is relatively unaffected by changes in instruments and procedures that impacted measurements in the early 1970s (van Wijngaarden and Vincent, 2005; Vincent et al., 2007).

The DTR, average daily temperature and relative humidity were computed for each station. These quantities as well as the daily precipitation were next averaged over all stations, and plotted separately for 2001 and 1977-2005. Fig. 1 shows the plot of the daily temperature, relative humidity, precipitation and DTR averaged over all stations. The data for 2001 are scattered close to the average observed for 1977-2005. The precipitation graph shows the most scatter which is expected as substantial amounts of rain/snow are delivered by large weather systems that take days to travel across North America.

The DTR was largest for stations in the prairies and smallest for coastal and Arctic stations. For example, for Calgary it varied from about 11 ^{o}C during the winter months to 13 ^{o}C in the summer while for Victoria the corresponding values were 5 ^{o}C and 10 ^{o}C, respectively. Generally, southern stations have maximum DTR during the summer while some Arctic stations such as Resolute and Baker Lake experienced the minimum DTR near summer solstice when these stations experience continuous sunlight.

3. RESULTS

The DTR values for 2001 fluctuate around the averaged results for 1977-2005 with a time scale of a few days. This coincides with the time for major weather systems having various cloud intensities to move across the country. No obvious inhomogeneity, having an amplitude larger than the fluctuations, is evident. The graphs for average temperature, relative humidity and precipitation behave similarly although the precipitation graph for 2001 exhibits large fluctuations about the values averaged for 1977-2005. This is not surprising as precipitation does not occur uniformly throughout the year.

The change in DTR observed immediately before and after Sept. 11, 2001 relative to the average DTR observed during 1977-2004, is shown in Fig. 2. This is significantly different from the results of the early study for the continental U.S. which found a negative change in the three-day averaged DTR for Sept 8-11 and Sept. 14-17 while the period Sept. 11-14 exhibited a positive change. Data was therefore examined for the 34 stations located south of 50^{o} N latitude. These stations are closest to regions of the continental U.S. that frequently have conditions favourable for contrail formation (DeGrand et al., 2000). Fig. 2 shows that with the exception of Sept. 14, the change in DTR for southern Canada is close to that found for all Canada. The DTRs were also averaged for stations west and east of the Ontario-Manitoba border, and found to be very similar to those found for all of Canada. Insight into the change in DTR observed during Sept. 8-17, 2001 relative to 1977-2004 was found by plotting the results for each station. Fig. 3 shows the results immediately before Sept. 11 as well as during and after the subsequent three-day period when flights were severely restricted. Only 7 stations exhibited a change in DTR exceeding two standard deviations from the average value observed during 1977-2004 on any of these four days. Stations in close geographic proximity experience a change in DTR having the same sign and similar magnitude. This is especially true of stations exhibiting the largest changes in DTR as is shown for stations in Alberta on Sept. 10 and 14. The consistency of observations at neighbouring stations shows there is data from a sufficient number of stations to reveal geographic patterns.

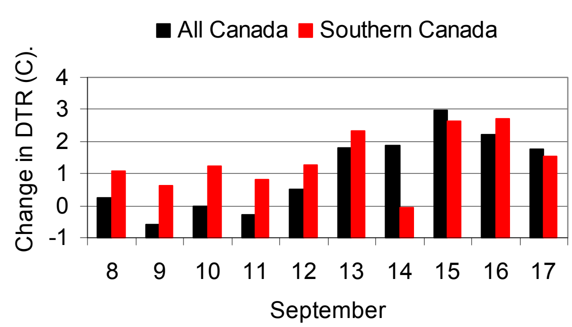

Fig. 2: Change in DTR observed in 2001 relative to average DTR observed in 1977-2004. The data for Southern Canada was found using 34 stations located south of 50^{o} N latitude.

Fig. 3 shows significant day to day changes in the DTR. On Sept. 10 many stations in Western Canada experience a negative change in DTR. This pattern has weakened by Sept. 12 and on Sept. 14 the same western stations exhibit a positive change in DTR. Similarly, stations in southern Ontario having a negative change in DTR on Sept. 10, indicate positive values on the

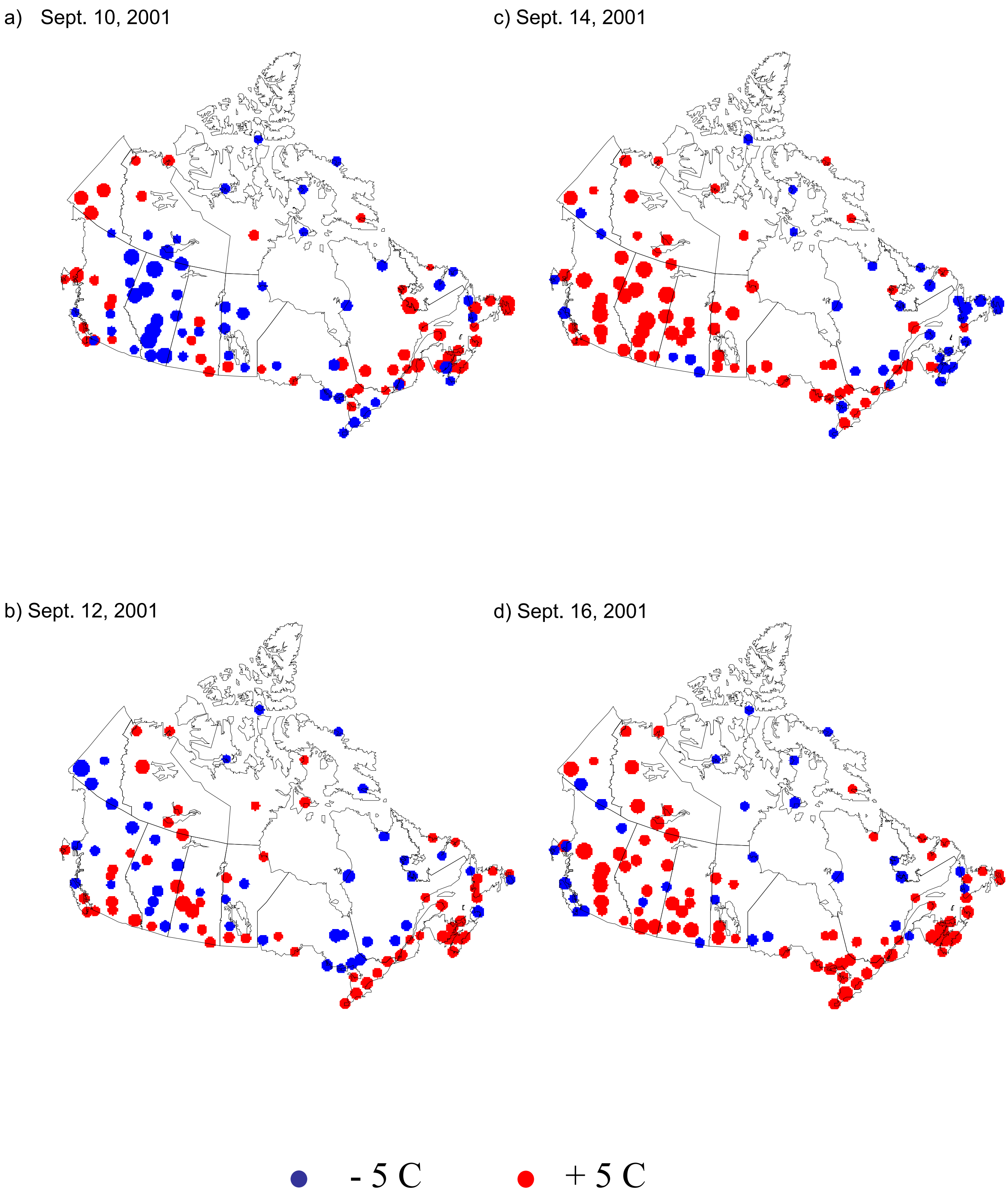

Fig. 3: Change in DTR relative to DTR averaged at each station for 1977-2004.

later dates while Maritime stations exhibiting a negative change in DTR on Sept. 14 show positive values on Sept. 16. Fig. 3 also shows that the small average change in DTR found for the 34 stations in Southern Canada on Sept. 14 occurs because the Maritime stations have a negative change in DTR while other southern stations experience a positive change in DTR.

The changes from negative to positive values shown in Fig. 3 first affect stations in Western Canada during Sept. 10 – 14 followed by stations in Central and Eastern Canada during Sept. 14 – 16. This is consistent with the movement of weather systems having different levels of cloudiness across the country. Caution must therefore be exercised when computing the average DTR experienced by all stations in Canada as the accuracy of any such number is not limited by the number of stations but by the different weather conditions that stations separated by thousands of kilometers experience.

4. CONCLUSIONS

This study did not find any inhomogeneity in average daily temperature, relative humidity and precipitation in Canada during September 2001. Moreover, no change in DTR similar to that found previously for the continental U.S. corresponding to the flight restrictions imposed after Sept. 11, 2001 was observed. It appears that day to day changes in DTR recorded at stations throughout Canada are consistent with the natural progression of weather systems across the country.

5. Acknowledgements

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6. References

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