SURFACE PRESSURE TRENDS IN THE CANADIAN ARCTIC DURING 1953-2003

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1. INTRODUCTION

A number of studies have found evidence for climate change in Canada during the past 50 years affecting temperature, precipitation (Zhang et al., 2000) and relative humidity (van Wijngaarden and Vincent, 2004). The observed changes are most significant during winter and spring. For example, winter temperatures in the Western Canadian Arctic have increased by up to several degrees centigrade during 1953-2003. These climate changes can be caused by changes in global circulation patterns.

It has been known for centuries that mild winters in northern Europe coincide with severe winters in southern Greenland and vice versa (Sturm et al., 2003). This correlation is believed to arise from the so called North Atlantic oscillation (NAO) whose strength is determined by the difference in air pressure over Iceland and the Azores. In 1998, it was suggested that the NAO is part of a much larger decadal oscillation affecting the entire northern hemisphere called the Arctic Oscillation (AO) (Thompson and Wallace, 1998). They reported a pressure decrease of 4 hPa over parts of the Arctic during winter over the period 1968-1997.

Nearly all of the work done to date has relied on records of sea level pressure which is calculated from the measured pressure by taking into the account the height of the observing station. Unfortunately, a variety of errors in this calculation have been found typically, due to unrecorded changes in manometer height (Graham and Slonosky, 2003).

The purpose of this work is to examine records of surface pressure recorded over the period 1953-2003. Hourly data recorded at 90 airport stations located throughout Canada were studied. The data set excluded the large urban centers of Montreal, Toronto and Vancouver whose metropolitan areas have expanded greatly 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%.

2. HOURLY MEASUREMENTS OF SURFACE PRESSURE

Trends in pressure were investigated for the different seasons and various times of the day. The average pressure 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).

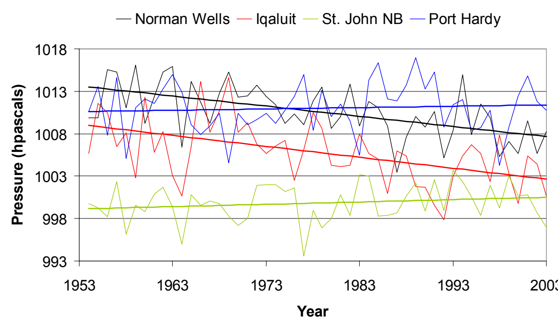

Fig. 1: Trend in Winter Surface Pressure for 4 Stations Located in Different Climate Zones. 1) Norman Wells, Northwest Territories, 2) Iqaluit, Nunavut, 3) St. John, New Brunswick and 4) Port Hardy, British Columbia.

A linear trendline was computed and fit to the data as shown in Fig. 1 which illustrates the change in average winter pressure for four stations located in distinctly different climate zones. Norman Wells and Nunavut are located in the Arctic while Port Hardy is situated on Vancouver Island, B.C. and St. John is located in New Brunswick on the east coast of Canada. A statistical t test was performed to determine whether this linear trend was significant at the 5% level. Both Norman Wells and Nunavut unlike the other two stations have a decreasing pressure trend over the period 1953-2003.

Fig. 2 shows the results for all stations in our study. The data represented in Fig. 2 was averaged over all 24 hours of the day as no

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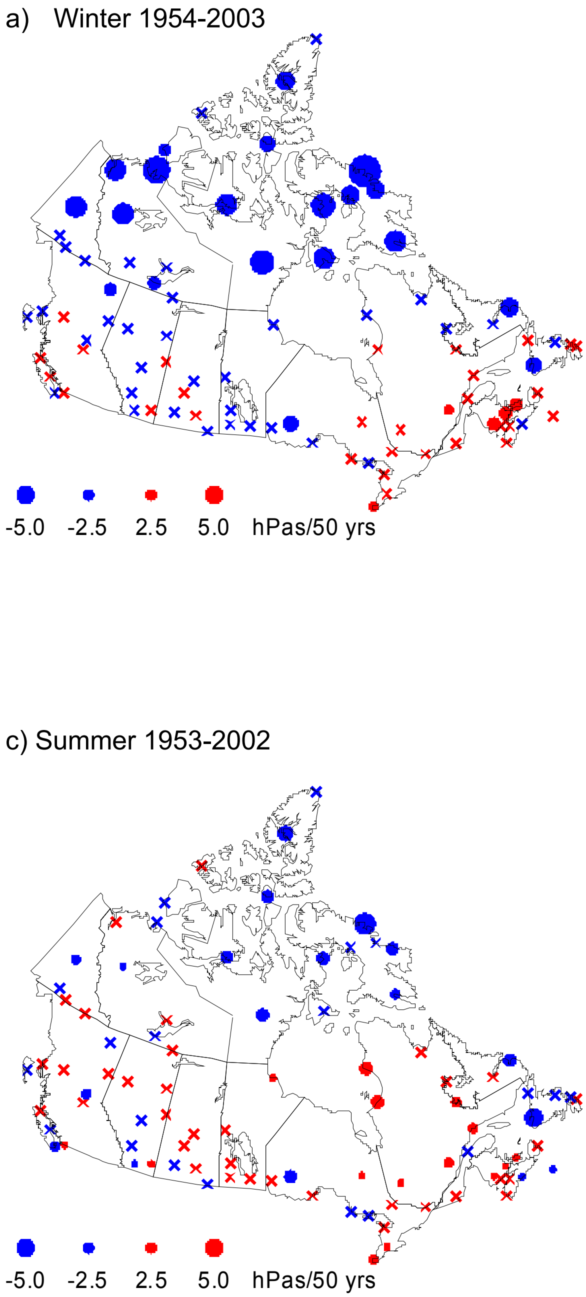

Fig. 2: Trend in Surface Pressure During a) Winter; b) Spring; c) Summer; d) Fall. Blue (red) dots represent decreasing (increasing) surface pressure statistically significant at the 5% level. Crosses represent insignificant trends.

discernible difference in pressure trends were found for night, morning, afternoon and evening. Figs. 2a shows a substantial decrease in relative humidity during the winter in the Arctic. Fewer and weaker statistically significant trends were found for these northern stations in the other seasons. In contrast, very few stations in southern Canada had significant trends in any seasons.

3. DISCUSSION OF RESULTS

The trend dependence for stations north and south of 60^{o} N latitude is summarised in Tables I and II.

Table I: Trends for Stations North of 60^{o} N Latitude

Season	Signif. Positive	Insignif. Positive	Insignif. Negative	Signif. Negative
Winter	0	0	8	16
Spring	0	2	11	11
Summer	0	6	8	10
Fall	1	10	9	5

Table II: Trends for Stations South of 60^{o} N Latitude

Season	Signif. Positive	Insignif. Positive	Insignif. Negative	Signif. Negative
Winter	5	29	27	4
Spring	13	35	13	4
Summer	15	29	14	7
Fall	3	31	24	7

There is a clear difference between the northern and southern stations during the winter. Two thirds of the northern stations have a significantly decreasing pressure trend in the winter. Moreover for these northern stations, the average of the significant negative trends measured in hPa/50 years is -5.8 in winter, -3.8 in spring, -2.9 in summer and -2.8 in fall.

4. CONCLUSIONS

There has been a substantial decrease in surface pressure during winter for stations in Canada lying north of 60^{o} north latitude during 1953-2003. The magnitude of the pressure decrease for these northern stations in the winter is about 0.5% of the total atmospheric pressure. It is unlikely that such a large trend could be caused by instrument malfunction. Pressure is a key parameter affecting aviation and strict instrumental checks/maintenance are done on a regular basis.

It will be interesting to see whether these trends continue in the future along with changes in other climate variables such as temperature and precipitation. In conclusion, it appears that records of pressure collected at Canadian stations during 1953-2003 confirm the existence of the Arctic Oscillation.

5. References

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