Temperature Trends in Southwestern Saskatchewan Revisited

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Introduction

Recently, in the 2007 report, IPCC (2007) concluded, using much stronger language than previously, 1) that 'global atmospheric concentrations of carbon dioxide (primarily due to fossil fuel use and land-use change), methane and nitrous oxide (primarily due to agriculture) have increased markedly as a result of human activities since 1750', 2) with '...very high confidence that the globally averaged net effect of human activities since 1750 has been one of warming...', 3) that 'warming of the climate system is unequivocal...'. Globally, of the 12 warmest years in the instrumental records, 11 have occurred within the past 12 years; thus, the past 12 years have contributed to maintaining or increasing the rate of warming (IPCC 2007). Further, preliminary analysis of weather data suggests 2006 was the warmest year in US history (Anonymous 2007).

Previously, we had analyzed long-term weather data (from 1950 to 1997) to study the annual as well as seasonal change in air temperature in the semiarid prairie near Swift Current, SK (Cutforth et al. 1999; Cutforth 2000). We found that the average annual maximum (T_{mx}) and minimum (T_{mn}) air temperatures had increased linearly with year. Seasonally, the average T_{mx} and T_{mn} for January through April (JFMA) had also increased linearly from 1950 to 1997, as had the average T_{mn} for May through August. Average air temperatures for September through December (SOND) did not change with year. Generally, JFMA experienced the largest warming trend between 1950 and 1997, whereas temperatures during SOND did not change with year.

Objective

In light of the recent remarks by IPCC (2007), we re-examined the air temperature data gathered at weather recording stations located within a 15000 km^2 tract of land south of Swift Current to see how annual and seasonal trends in temperature from 1950 to 1997 compare with those from 1950 to 2006.

Methods

Daily maximum (T_{mx}) and minimum (T_{mn}) air temperatures were recorded at Aneroid, Gravelbourg, Maple Creek, Shaunavon and Swift Current in southwestern Saskatchewan from 1950 to 2006 (Fig. 1). All weather recording sites were manned by volunteers (except Swift Current) using equipment maintained and calibrated by Environment Canada. Average annual and average seasonal - JFMA (January, February, March, April), MJJA (May, June, July, August) and SOND (September, October, November, December) - T_{mx} and T_{mn} for the region were determined from the daily temperatures averaged across locations.

Results

Of the past 9 years from 1998 to 2006, about 60% were in the warmest 20 years since 1950 but only about 30% were in the warmest 10 (Table 1). This result is quite different from IPCC (2007) who found that for global surface temperature, 11 of the past 12 years ranked among the 12 warmest years on record. However, the rankings suggest that warming trends have continued in southwestern Saskatchewan, with 2006 having some of the warmest average annual and seasonal T_{mn} on record (Figs. 2 to 5).

All warming and non-warming trends determined from data collected from 1950 to 1997 continued through 2006. The rates of change from 1950 to 2006 were very similar to those from 1950 to 1997. For those seasons with significant trends, the trend equations for 1950 to 1997 were not significantly different from those for 1950 to 2006 (Table 2). Average annual T_{mx} and T_{mn} continued to increase linearly with year between 1950 and 2006; the overall increase was about 2.1EC (Fig. 2). Seasonally, the largest temperature increase (4.7EC from 1950 to 2006) occurred in JFMA with both T_{mx} and T_{mn} increasing linearly since 1950 (Fig. 3). There was a linear increase in T_{mn} for MJJA with an overall increase in T_{mn} of 1.1EC, however there wasn't any detectable linear trend in the average T_{mx} with year (Fig. 4). Temperatures did not change during SOND (Fig. 5).

Comparing 1950-1997 to 1950-2006, the rate of warming of the annual average T_{mn} increased slightly, whereas the rate of warming decreased slightly for both T_{mx} and T_{mn} in JFMA (Table 1). The recent warming tendencies for SOND have contributed positively to the slight increase in the annual warming trend. With regards to past climate trends, SOND had been relatively inert compared to the other seasons, but that appears to be changing. Overall, comparing 1950-1997 to 1950-2006, the annual and seasonal temperature trends were positive (warming) and shifted towards higher significance. This was especially noticeable for T_{mn} of SOND whose significance increased from $P<0.91$ for 1950-1997 to $P<0.14$ for 1950-2006.

Conclusions

The annual and seasonal temperature trends determined from weather data collected from 1950 to 1997 continued at similar rates with the addition of data from 1998 to 2006. Generally, over a large area within southwestern Saskatchewan, annual average temperatures have continued to increase; seasonally, JFMA continued to experience the largest warming trend whereas SOND has not warmed since 1950.

References

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Table 1: Of the past 9 years (1998-2006), the number of years ranked in the warmest 10 and in the warmest 20 compared to the 57 years from 1950 to 2006.

Ranking	Annual		JFMA		MJJA		SOND	
	T_{mx}	T_{mn}	T_{mx}	T_{mn}	T_{mx}	T_{mn}	T_{mx}	T_{mn}
warmest 10	5	3	1	1	3	4	2	3
warmest 20	7	5	6	7	4	5	5	6

Table 2: Regression equations describing the linear relationship of annual and seasonal (JFMA - January through April, MJJA - May through August) air temperatures to year from 1950 to 1997 and from 1950 to 2006.

Time	Equation	
	1950-1997	1950-2006
Annual	T_{mx} = -52.2 + 0.03178*Year T_{mn} = -71.3 + 0.03498*Year	T_{mx} = -53.2 + 0.03229*Year T_{mn} = -8106 + 0.04021*Year
JFMA	T_{mx} = -184.8 + 0.09389*Year T_{mn} = -185.0 + 0.08823*Year	T_{mx} = -165.1 + 0.08387*Year T_{mn} = -172.4 + 0.08182*Year
MJJA	T_{mn} = -30.3 + 0.01965*Year	T_{mn} = -29.9 + 0.01946*Year

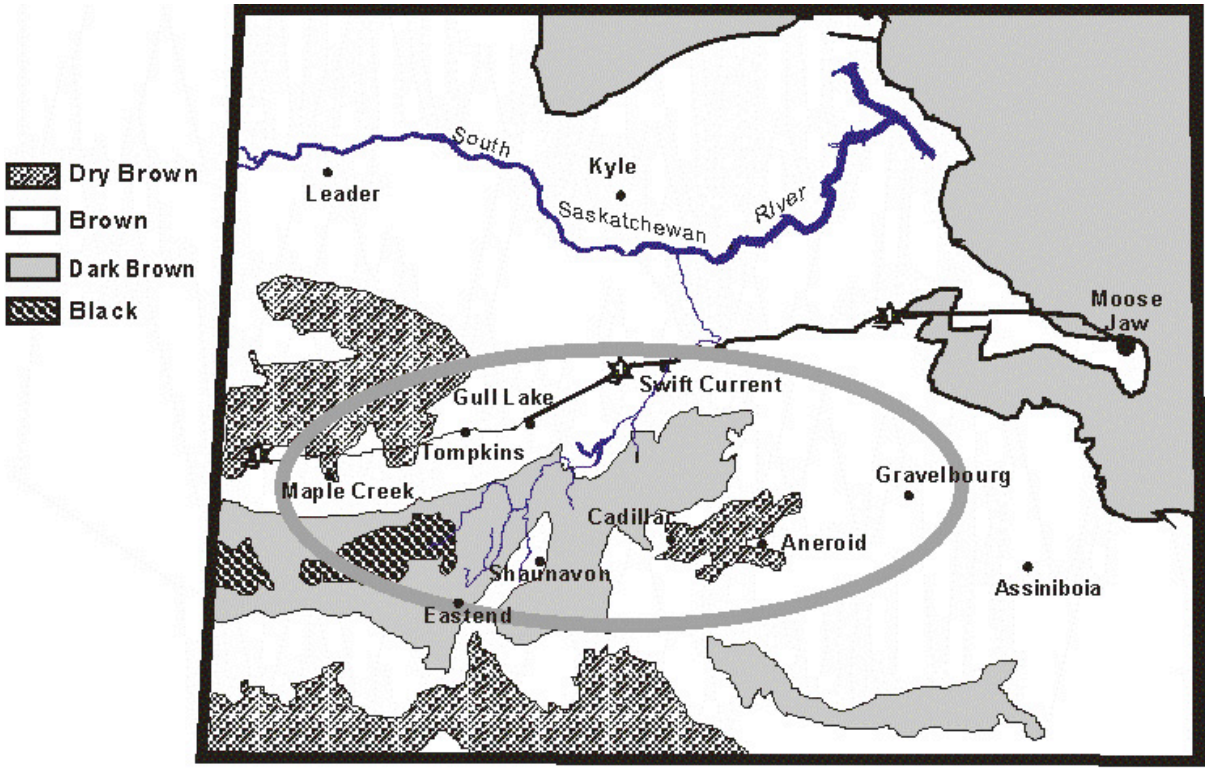

Figure 1: Location of the weather recording sites in southwestern Saskatchewan. Circled is the approximate area over which the environmental measurements chosen to detect climate change apply.

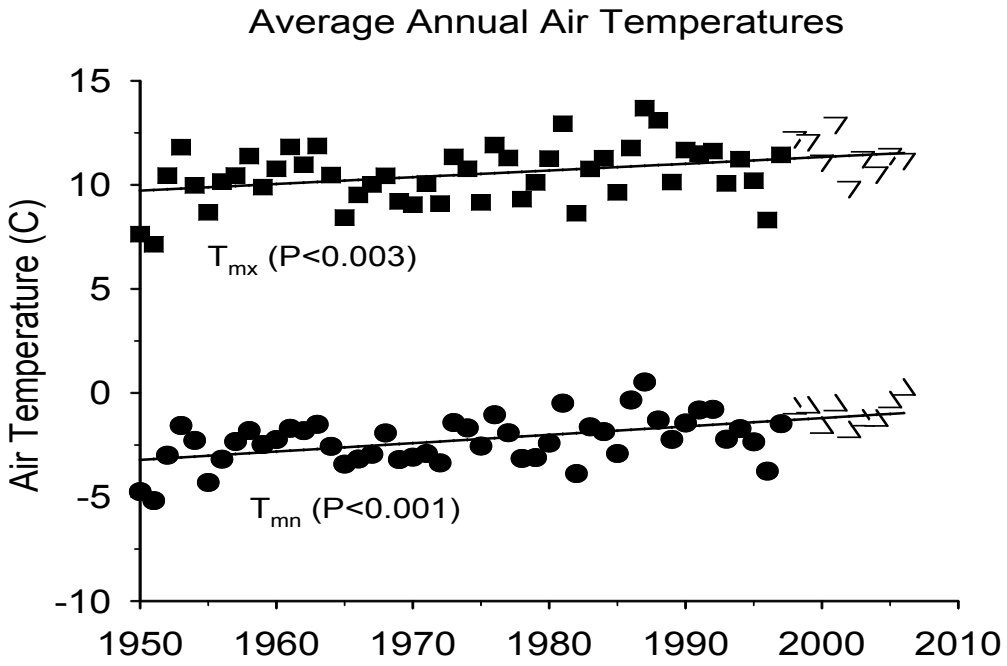

Figure 2: The relationships of the annual average maximum (T_{mx}) and minimum (T_{mn}) air temperatures with years. Lines represent linear relationships between temperature and years from 1950 to 2006. Triangles represent the years from 1998 to 2006.

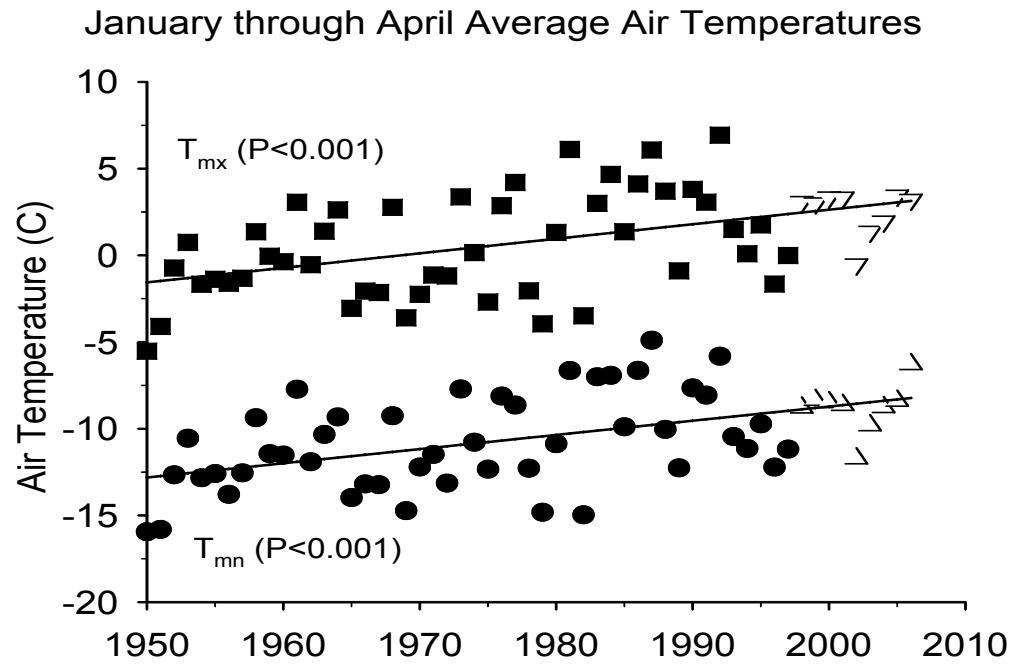

Figure 3: The relationships of the seasonal (January through April - JFMA) average maximum (T_{mx}) and minimum (T_{mn}) air temperatures with years. Linear relationships are between temperature and years from 1950 to 2006. Triangles represent the years from 1998 to 2006.

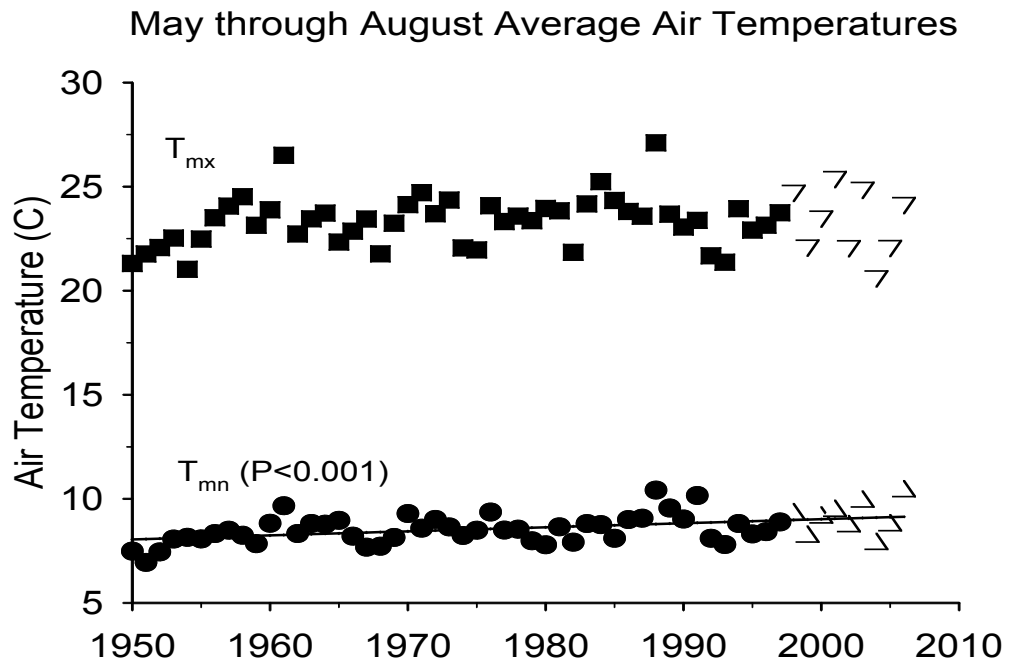

Figure 4: The relationship of the seasonal average maximum (T_{mx}) and minimum (T_{mn}) air temperatures for May through August (MJJA) with years. Linear relationship for T_{mn} is between temperature and years from 1950 to 2006. Triangles represent the years from 1998 to 2006.

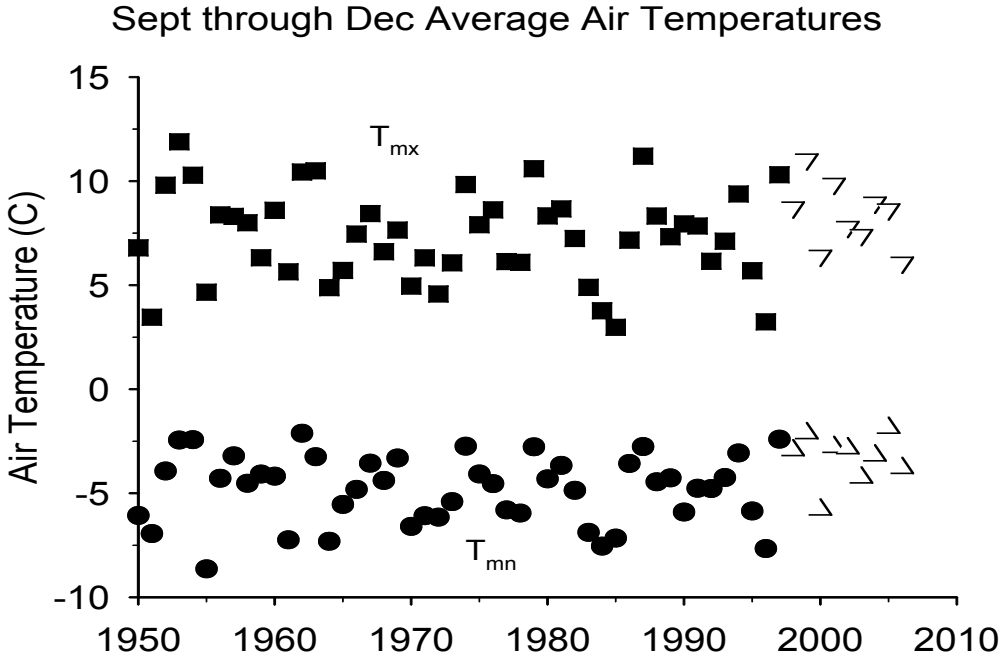

Figure 5: The relationship of the seasonal average maximum (T_{mx}) and minimum (T_{mn}) air temperatures for September through December (SOND) with years. Triangles represent the years from 1998 to 2006.