1.12 SUMMERFALLOW TRENDS AND CLIMATE IN THE CANADIAN PRAIRIES

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1. INTRODUCTION

Global warming associated with anthropogenic greenhouse gas emissions is of great concern due to its potential threat to ecological systems, including threats to agricultural production systems. In turn, land surface changes associated with agricultural practices may have an influence on local, regional and even global climate. Such effects may have attenuated climatic trends associated with global warming, and have caused cooling, thus masking part of the climate change signals, especially at local and regional scales.

This paper presents an example that demonstrates climatic trends in the Canadian Prairies which are associated with historical changes in the agricultural practice of summerfallow. Summerfallow is a practice used to conserve soil moisture and consists of leaving land fallow over a growing season, keeping it free of vegetation for 18-20 months. It has been used in the Canadian Prairies for over a century and at one time extended to over 11 Mha, or about a quarter of Canada's cultivated land. Between 1951 and 1976 the area under summerfallow increased from 8.7 to 11.4 Mha. Subsequent to 1976, improvements in land management practices resulted in significant reductions to areas under summerfallow, reaching a value of 5.4 Mha by 2001, and expected to further decrease to 3.5 Mha in th[1]e future (Dumanski et al., 1998).

The effect of the decrease in summerfallow area, and corresponding increase in agricultural crops would likely have the greatest effect on local and regional climate between the mid-June and mid-July period, during the peak of the growing season, when agricultural crops have the highest leaf area index and maximum transpiration. Raddatz (2000; 2005) has shown that agricultural crops are an important source of water vapour and summer rainfall in the Canadian Prairies. It has also been shown that increased moist deep convection and severe storm events coincide with the peak crop growth period (Raddatz, 1998; Raddatz and Cummine, 2003). It is expected that evaporation from fallow land would amount to only about 30% of the transpiration from croplands (Raddatz, 2000), and that there is a greater tendency for the occurrence of deep convective clouds and rainfall over croplands (Rabin et al., 1990; Segal et al., 1995; Pielke, 2001).

A previous study analyzed 1951-2000 climate trends in maximum temperature, minimum temperature, diurnal temperature range, solar radiation and precipitation in different regions of the Canadian Prairies (Gameda et al., 2006). The current study looks at trends in cloud cover over the Prairies for the corresponding period. Preliminary findings of this study are presented here.

2. METHODOLOGY

Summertime (June, July, August, JJA) cloud data for the 1953-2002 period were compiled for four meteorological stations, Lethbridge, Regina, Winnipeg and Medicine Hat, within the Canadian Prairies. Cloud amount was classified as portions (from zero to 10) of the whole sky covered by clouds. A cloud amount of zero indicates a clear sky, while a value of 10 indicates an overcast sky. Daytime (9am-4pm) and nighttime (9pm-4am) cloud data were compiled separately. For each subset, monthly frequencies of the occurrence of each portion of cloud amounts (zero to 10) and monthly mean cloud amounts were also compiled. Trend analysis was carried out on cloud data, for the 1953-1975 and 1976-2002 periods, corresponding to high and declining summerfallow area, respectively.

The main assumption of the study was that, with declining summerfallow amounts and corresponding increases in areas under

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agricultural crop, there would likely be an increase in cloud cover and amounts over the 1976-2002 period due to increased transpiration from crops. Increasing clouds would contribute to reductions in incoming solar radiation and result in reductions in maximum air temperature and an increase in minimum air temperature.

Since convective systems are more likely to develop in the afternoon and early evening, cloud data for these periods are more relevant to this study. However, as data were only available in daytime and nighttime segments, we have used daytime cloud data to evaluate trends that might correlate with changes in summerfallow area.

Trend analyses were performed for June-July and June-July-August averages. However, only the results for June-July are discussed as these correspond closest to analyses previously conducted on other climate variables (Gameda et al., 2006).

3. RESULTS

Consistent trends in the frequency of cloud cover over the two periods under study were observed. For the 1953-1975 period, all four stations displayed some reduction, ranging between 2 to 5 %, in the frequency of occurrence of overcast skies (Fig. 1). For the 1976-2002 period, the two stations from southern Alberta, Lethbridge and Medicine Hat, showed no notable changes in the frequency of occurrence of overcast skies, whereas the Regina and Winnipeg stations displayed considerable increases in cloud cover. A previous study had shown that trends in the Canadian Prairies over this period displayed a significant reduction in June 15 – July 15 maximum air temperature, and incoming solar radiation, and a substantial increase in precipitation (Gameda et al., 2006).

The frequency of occurrence of clear skies did not display any consistent trends over the 1953-1975 period. On the other hand, for the 1976-2002 period, three of the four stations studied displayed notable reductions in the frequency of occurrence of clear skies, in the range of 1 to 5 %, while the Lethbridge station indicated a marginal increase in this variable. Some of the discrepancies may be due to serial correlation of the time series under consideration. In order to minimize this, statistical analyses were carried out using the trend analysis methodology employed in Gameda et al. (2006). The results from the analysis are shown in Table 1. For example, the marginal increase in the frequency of occurrence of clear skies at Lethbridge actually shows up as a weak decrease. As can be noted from Table 1, trends for cloud parameters are not always consistent at all stations, although significant trends were found for particular variables at individual stations. Moreover, the changes in the amount of area under summerfallow have been compiled for the whole of the Prairies. There may however be considerable differences in the regional distribution of these areas within the Prairies, which may have some influence on local climate.

There were no distinguishable trends in the mean amount of cloud cover (Fig. 3) over the 1953-1975 period. There was, however, a positive trend over 1976-2002, although the positive trend at the two Alberta stations is not significant. The increase in mean amount of cloud cover is about 1/10 over the period at the two other stations, Regina and Winnipeg, a substantial change.

In general, trends in the variables studied showed tendencies that are consistent with a decrease in summerfallow area, but were not definitive for several reasons: i) The cloud dataset was limited to daytime and nighttime segments. A dataset for the afternoon and early evening period would have been more likely to reflect the effect of convective cloud formation resulting from transpiration from agricultural crops; ii) A dataset for the June 15-July 15 period, the period of focus in Gameda et al. (2006), would have been more reflective of the period of peak crop growth; iii) An identification of the pattern of changes in summerfallow area within the Prairies would be helpful in determining linkages between regional land use change and climate.

4. CONCLUSIONS

This study shows that there is some evidence to indicate that in the Canadian Prairies, over the 1976-2002 period, corresponding to the period of declining summerfallow area, there have been significant trends in the frequency of occurrence of daytime clouds. These trends suggest that there have been decreases in the frequency of clear skies, and increases in the frequency of overcast skies and mean cloud amount corresponding to the trends in reduction of summerfallow.

In comparison to these findings, climate change associated with global warming is more likely to result in increases in nighttime clouds and daily minimum temperatures.

These findings, in conjunction with those previously reported (Gameda et al., 2006) suggest clear linkages between changes in summerfallow use and regional climate.

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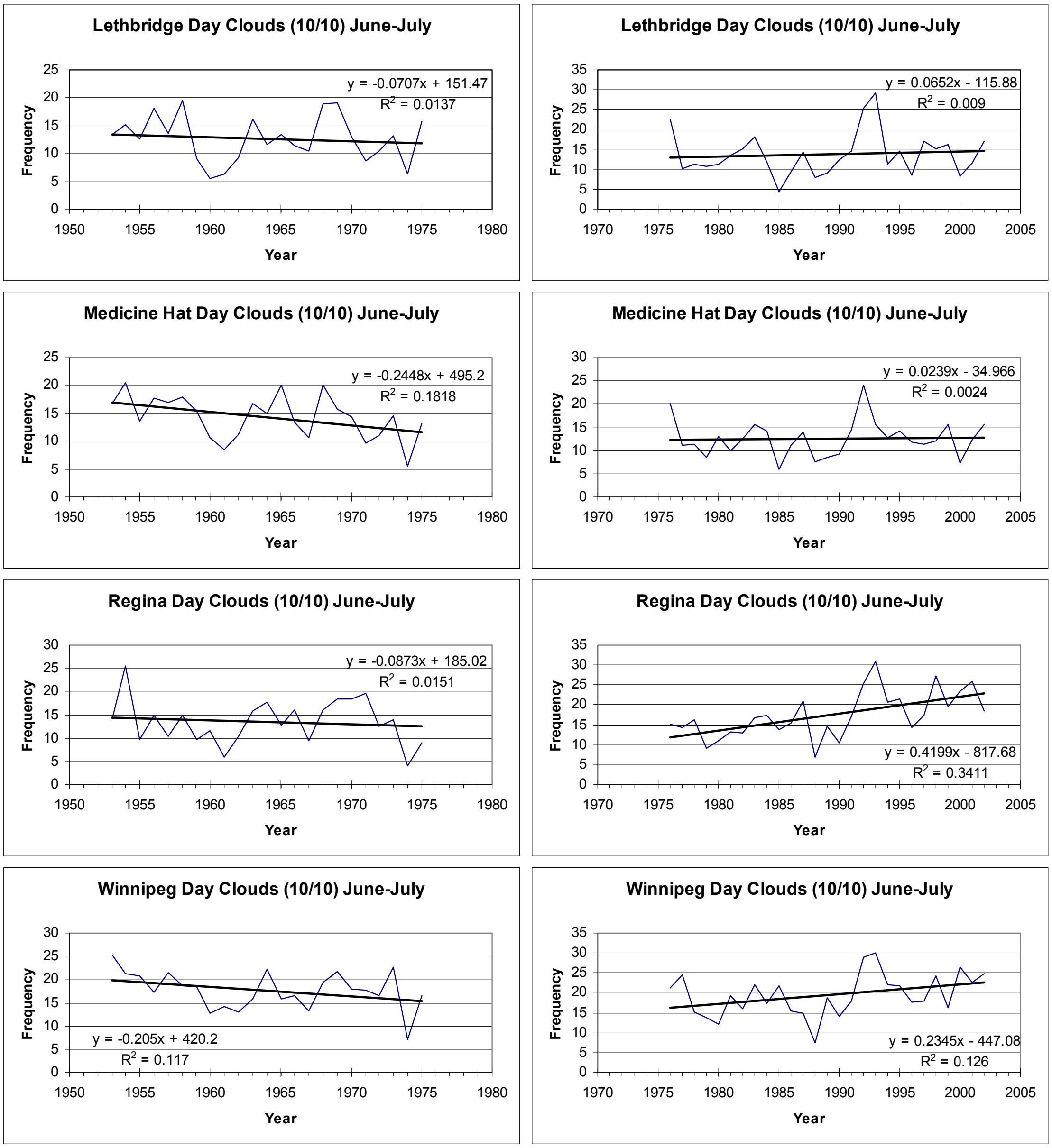

Fig. 1 Time series of June-July frequency of complete cloud cover at four Prairie stations and corresponding linear trends.

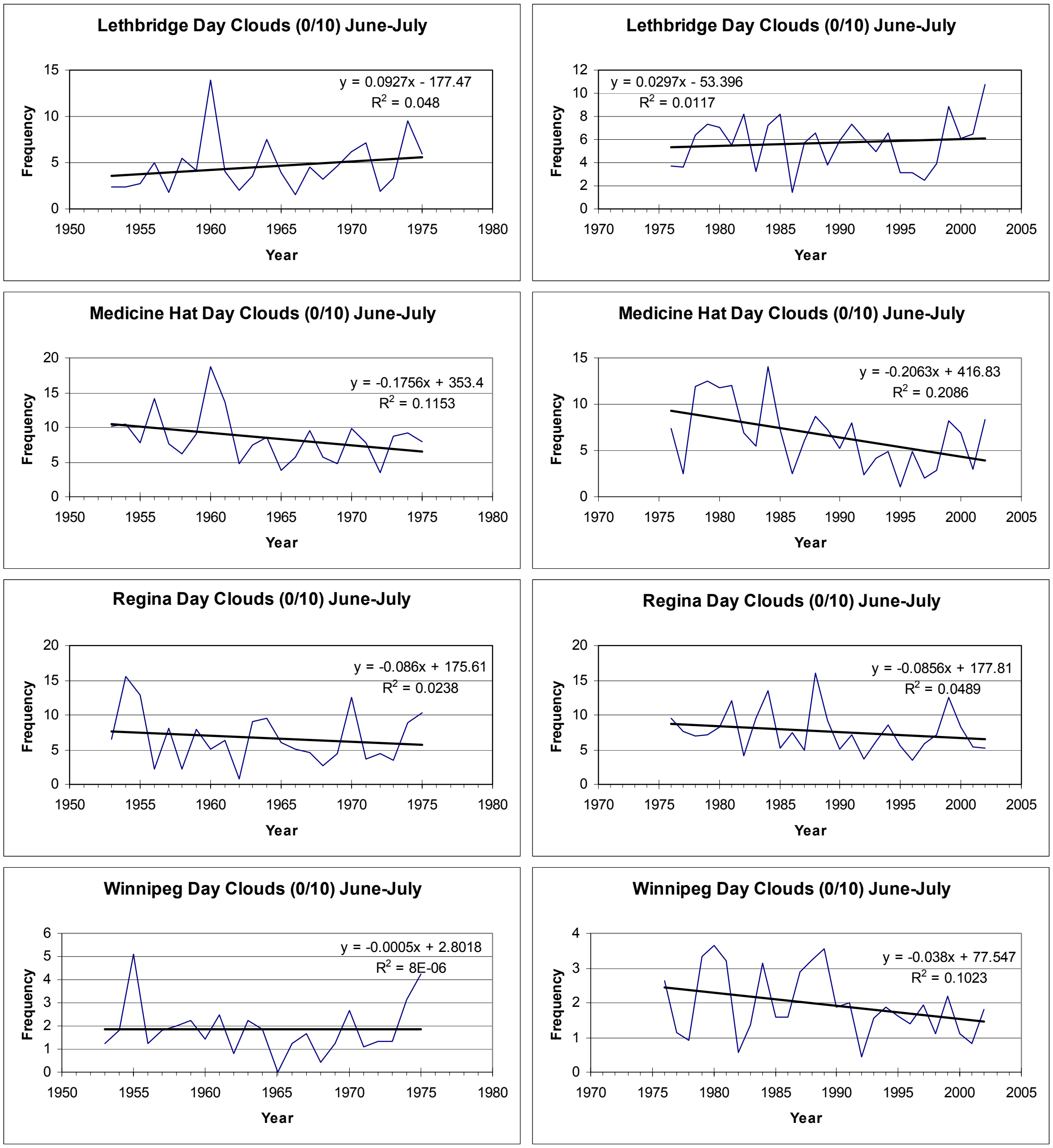

Fig. 2 The same as in Fig.1 but for the frequency of occurrence of clear skies.

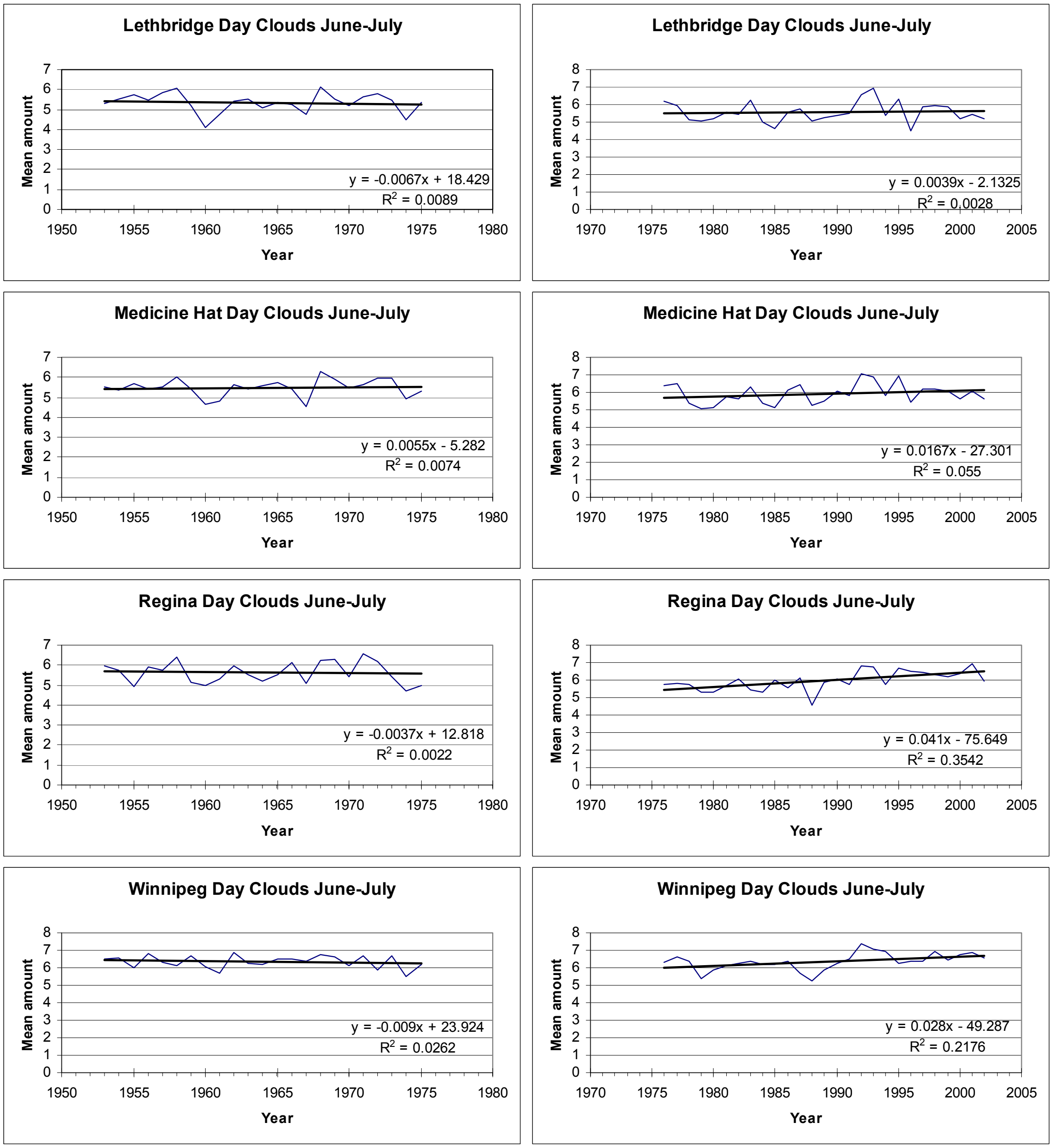

Fig. 3 The same as in Fig.1 but for the mean amount of cloud cover.

Table 1. Trends in June-July Daytime clouds data

Parameter	0/10		10/10		Mean amount	
Period	1953-1975	1976-2002	1953-1975	1976-2002	1953-1975	1976-2002
Lethbridge	0.10	-0.04	-0.11	0.14	-0.02	0.02
Medicine Hat	-0.16	-0.29*	-0.27	0.09	0.01	0.03
Regina	-0.24	-0.06	0.16	0.51*	0.02	0.05*
Winnipeg	-0.03	-0.05	-0.12	0.30	-0.00	0.03*

Note: parameters for 0/10 and 10/10 denote frequencies in percentage, and mean amount is cloud cover in tenths. Asterisked trend values are statistically significant at the significance level 0.05.