Precipitation Trends on the Canadian Prairies*

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ABSTRACT

The Canadian prairies are a major producer of grain, much of which is produced under rain-fed agriculture. The amount and timing of precipitation are critical to grain production. Information on the precipitation trend is therefore vital to this region. Regression analysis was used to establish linear trends of precipitation amounts, number of precipitation events, and variance of precipitation at 37 stations with 75 yr of record across the Canadian prairies. The precipitation was further split into rainfall and snowfall, and similar analysis was performed on these variables. The analysis showed that there has been a significant increase in the number of precipitation events mainly due to an increase in the number of low-intensity events. As such, precipitation events are not getting more intense on the Canadian prairies. The number of precipitation events (excluding events that are 0.5 mm or less) has increased by 16 events during the last 75 yr. Precipitation and rainfall amounts have increased significantly by 0.62 and 0.60 mm yr^{-1}, respectively, on the Canadian prairies during the last 75 yr. During the period from 1921 to 1960 the trends in precipitation, rainfall, and snowfall were not statistically different from zero. However, from 1961 to 1995, snowfall has declined significantly by 0.95 mm yr^{-1}. The trends in the most recent period (1961–95) were also significantly different from those in the 1921–60 period for snowfall. The difference in trends between the two periods for snowfall, combined with the inverse relationship in the rainfall–snowfall trends, suggest that these trends may be related to climate change.

1. Introduction

The increase in atmospheric concentration of greenhouse gases, as a result of human activities, is well established (Rotty and Masters 1985). While these gases are believed to augment the natural greenhouse effect resulting in a warming trend, direct evidence for this is not yet certain (Schneider 1994). Along with global circulation model (GCM) simulation experiments, historical records are examined for evidence of a trend in climate for the period coinciding with increases in the greenhouse gases (Bootsma 1994; Idso and Balling 1991). This provides a means of validating some of the GCM projections. Trend analyses have shown that, while there is a warming trend in the historical records, the degree of warming is small compared to that simulated by GCMs (Karl et al. 1991; Skinner and Gullet 1993; Manson 1995).

An analysis of 100 yr of historical air temperature records in Canada revealed a significant warming trend of 1.1°C century^{-1} (Skinner and Gullet 1993). The trend in minimum (mostly nighttime) temperature was 1.5°C century^{-1}, which was twice that of maximum (mostly daytime) temperature. They concluded that significant decreases in mean temperature range (an important measure of climate variability) occurred in most regions during all seasons. This reduced temperature range has been attributed to increasing cloud cover, which is relevant to the precipitation trend. As cloud formation is a precursor of precipitation, increasing cloud cover may be associated with precipitation events.

The inherent spatial and temporal variability of precipitation events makes this variable an unlikely candidate to be used as an indicator of climate change. The annual and monthly variability of precipitation are often an order of magnitude greater than the change a trend analysis is supposed to detect. Bootsma (1994) reported that simple linear correlation analysis of precipitation with time was significant at two of the five Canadian weather stations (with 100 yr of precipitation record) considered in his study. The Agassiz station in British

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Columbia (on the west coast) had a negative trend in precipitation, which was accompanied by a decrease in variability, while Charlottetown in Prince Edward Island (on the east coast) had a positive correlation coefficient and an increase in variability from the 1890s. While such studies provide vital site-specific information, the regional implication cannot be deduced from the results of a few stations. Groisman and Easterling (1994) reported an area-average linear trend of 13.17% (1.28 mm yr^{-1}) during a period of 100 yr over southern Canada. However, according to Metcalfe et al. (1997) the correction factor used by Groisman and Easterling (1994) to homogenize Canadian rainfall data was only one-half of that required to reconcile the differences between the two gauges used in Canada since 1930.

There are problems associated with the use of records from individual stations in the study of climatic trends (Bootsma 1994). The most important of these is that individual station records can become inhomogeneous due to (a) urbanization; (b) change in the time of observation or climatological day; (c) change in instrumentation, as in the case of automation; (d) change in station location; and (e) change in microclimate at the station. A challenging problem in the study of precipitation trend is inhomogeneity of historical precipitation data. The historical precipitation data across Canada are inhomogeneous due to several changes in the measurement techniques (Groisman and Easterling 1994; Metcalfe et al. 1997).

In the 1960s the ruler method of measuring snowfall (with a 10:1 conversion ratio) was replaced by a Nipher gauge, which measured snowfall directly. According to Metcalfe et al. (1997), the Canadian Nipher shielded snow gauge is the standard instrument at about 125 stations, while about 1800 stations still estimate snowfall precipitation from ruler measurement. For rainfall, the Meteorological Service of Canada (MSC) gauge, introduced in 1930, was replaced with the Type-B gauge around 1975. Details of changes in measurement technology for snow and rainfall, and the systematic errors that are introduced to the time series, are provided by Groisman and Easterling (1994) and Metcalfe et al. (1997).

The Canadian prairie is an important producer of grain, most of which depends on precipitation. Information on the precipitation trend in this region is vital due to this dependency. The objective of this study is to examine trends in the precipitation amounts, variability of precipitation, and number of precipitation events at climatological stations with at least 75 yr of precipitation records.

2. Methods

a. Historical weather data

The weather data used in this study were obtained from the Environment Canada Archive for the three prairie provinces (Alberta, Saskatchewan, and Manitoba). These data are part of the Nat Christie database used in a climate change study, and this database was recently updated to include data up to 1995. We searched for stations across the prairie with 75 yr of complete precipitation record and found 49 stations.

Our initial analysis included all 49 weather stations; however, the lack of homogeneity at several of these stations resulted in their elimination from further analysis.

b. Addressing the problem of inhomogeneity

The implication of the changes in the measurement techniques is that historical precipitation data cannot be used for rigorous trend analysis until the inhomogeneities are identified and adjustments are made to the data to remove them. For snow, correction for inhomogeneity caused by the introduction of Nipher gauges can be accomplished using the method of Groisman and Easterling (1994). However, as only a limited number of weather stations use this gauge for snow measurement, we eliminated all stations with Nipher gauges from our analysis. Of the 49 stations used in our preliminary analysis, 12 had the Nipher gauge installed, leaving 37 stations across the prairie. The time series of snow at these 37 stations remains homogeneous as the measurement technique was unchanged. For rainfall, Groisman and Easterling (1994) used a correction factor of 1.025, based on the results of Goodison and Louie (1986), to account for changes in gauge type. Metcalfe et al. (1997) reported a correction factor of 1.05 for the average mean monthly rainfall from studies conducted across Canada. The latter factor accounted for both the difference in gauge type and wetting loss. We corrected the historical rainfall data by increasing daily rainfall prior to 1975 by a factor of 1.05 in accordance with the results of Metcalfe et al. (1997).

A more comprehensive approach to account for inhomogeneity will be the correction of rainfall events on a daily basis for all known errors including wind factor, wetting loss, and evaporation. However, this requires more detailed information on daily measurements than is currently contained in our database. For example, correction for wetting loss requires a knowledge of the number of times in a day the gauges were read; and to remove errors due to evaporation requires information on the time between the end of rainfall and when the gauges were read. With our simple approach there is a possibility of instability of classes with time due to instrument changes, especially with the small events included in classes 1 and 2.

c. Test of the intensification hypothesis

It has been suggested that the hydrological cycle of the earth as a whole will be intensified by greenhouse warming (Idso and Balling 1991). Consequently, climatic events may become more intense with climate

TABLE 1. Distribution of precipitation events and amounts in five classes—mean of a 75-yr time series on the Canadian prairie.

	Range (mm)	Number of events	Standard deviation	Amounts (mm)	Standard deviation (mm)
Precipitation					
Class 1	0–0.5	11.6	2	3.7	0.8
Class 2	0.5–5	52.6	6.2	109.8	15.1
Class 3	5–10	16.3	1.8	111.9	11.9
Class 4	10–25	10.7	1.4	159.8	21.2
Class 5	>25	2.4	0.6	90.5	24.7
Total		**93.6**	**8.7**	**475.7**	**55.0**
Rainfall*					
Class 1	0–0.5	5.2	2.1	1.6	0.8
Class 2	0.5–5	30.6	4.6	64.6	10.4
Class 3	5–10	9.7	1.3	68.9	9.7
Class 4	10–25	7.6	1.1	116.6	18.1
Class 5	>25	2.1	0.6	78.6	22.8
Total		**55.2**	**7.9**	**330.3**	**47.8**
Snowfall					
Class 1	0–0.5	6.9	1.5	2.2	0.5
Class 2	0.5–5	23.4	3.4	47.8	8.2
Class 3	5–10	6.8	1.5	43.8	8.9
Class 4	10–25	3.0	0.8	41.5	11.6
Class 5	>25	0.3	0.2	10.1	6.0
Total		**40.3**	**5.3**	**145.4**	**26.5**

* Note that the sum of rainfall and snowfall amounts and number in each class may not add up to that of precipitation due to days with both rainfall and snowfall. However, total amount of precipitation is the sum of the total rainfall and snowfall.

change. With precipitation, for example, the number of big downpours may increase while the number of small precipitation events declines. The historic precipitation records were examined for signs of the intensification of climatic events. This was carried out by dividing the annual precipitation into five classes. Class 1 contained the number of precipitation events in the range of 0–0.5 mm, which was expected to isolate small events and trace amounts. Although a trace amount is defined as a precipitation event that is less than 0.2 mm, we increased the limit of precipitation in class 1 to 0.5 mm to ensure that this class captures all small events. As a result of possible inhomogeneity in the definition of trace, and our lack of correction of trace amounts, we did not include class 1 in our trend analysis. Class 2 ranged from 0.5 to 5 mm, class 3 ranged from 5 to 10 mm, and class 4 ranged from 10 to 25 mm, while class 5 contained the number of precipitation events that were greater than 25 mm. While classes 2 and 3 represented ‘‘small’’ events, classes 4 and 5 contained the ‘‘big’’ precipitation events. In addition to these five classes, we generated another class, class 6, as the sum of classes 2 to 5, the total number of precipitation events larger than trace amounts in a year. We examined each of these five classes (2–6) for trends and to see whether the pattern of the trends agree with the intensification hypothesis, that is, a reduction in the number of events in the lower classes (classes 2 and 3) with a corresponding increase in the number of events in the higher classes (classes 4 and 5) with time. We defined a precipitation event as any day with a measurable amount of precipitation.

d. *Statistical analysis*

Regression analysis was used to establish linear trends of precipitation amounts, number of precipitation events, and variance of precipitation at 37 stations across the Canadian prairie. We used the *t* test to determine if the linear trends were significantly different from zero at the 5% probability level. The total precipitation was further split into rainfall and snowfall, and similar analysis was performed on these parameters using the 75-yr record. We employed the method of Balling (1996) to calculate the variance of precipitation and the trend of this variance. As well, 5-yr running means of annual precipitation and number of precipitation events were calculated and graphed for selected stations in the three prairie provinces.

3. Results and discussion

a. *Statistical characteristics of annual precipitation*

On the Canadian prairie, the annual mean precipitation was 475.7 mm from a total of 94 precipitation events during the last 75 yr (Table 1). Of this amount, rainfall accounts for 70% while snowfall makes up the remaining 30%. The most frequent precipitation events on the prairie were class 2, with more than 50% of annual precipitation events. However, class 2 constituted 23% of the amount of precipitation. On the other hand, only 2.5% of annual events were in class 5, but the amount of precipitation in this class was 19% of the total. Classes 3 and 4 were intermediate in frequency between classes 2 and 5, while class 4 provided the

TABLE 2. Trends in number of precipitation events in different intensity classes at six selected stations on the three Canadian prairie provinces.

	(Alberta)		(Saskatchewan)		(Manitoba)	
Parameters	Olds	High River	Whitewood	Biggar	Birtle	Minnedosa
Class 2*	**0.240****	**0.581**	**0.469**	−0.022	**0.325**	**0.219**
Class 3	**−0.054**	**0.136**	0.033	0.010	**0.064**	−0.001
Class 4	0.017	0.009	−0.012	0.022	0.010	0.005
Class 5	−0.013	**−0.056**	−0.016	**−0.012**	−0.005	−0.006
Class 6	**0.189**	**0.670**	**0.474**	−0.001	**0.394**	**0.217**

* Numbers of precipitation events in the range of 0.5–5, 5–10, 10–25, and >25 mm. Class 6 is the sum of classes 2–5.

** Numbers in boldface type are significantly different from zero.

highest amount of precipitation (33% of the total). The rainfall pattern is similar to that of total precipitation. The main difference between rainfall and snowfall is that snowfall contains more low-intensity classes than rainfall. For example, class 2 contributed 20% of the total amount of rainfall, while it accounted for 33% of total snowfall (Table 1). The characteristics of precipitation on the prairie suggest that a change in the frequency of class 2 would have a small impact on the total precipitation compared to changes in other higher classes.

b. *Intensification of precipitation*

There were discernible trends in the number of precipitation events in the different intensity classes at individual weather stations (Table 2). However, the pattern of these trends did not agree with what would be expected from the intensification hypothesis. In general, we found significant increases in the number of low-intensity classes, class 2 in particular, with corresponding decreases in the number of high-intensity events (class 5). The trends of the high-intensity classes were not significant ($P \leq 0.05$) in most cases, possibly due to the small size of the high-intensity classes (Table 1). The total number of precipitation events, class 6, also displayed significantly positive trends during the past 75 yr at most of the stations analyzed (Table 2). The bulk of the trend in class 6 is made up of the trends in class 2. Therefore, we conclude that there were significant increases in the number of precipitation events at several stations on the Canadian prairies, mainly due to an increase in the low-intensity events.

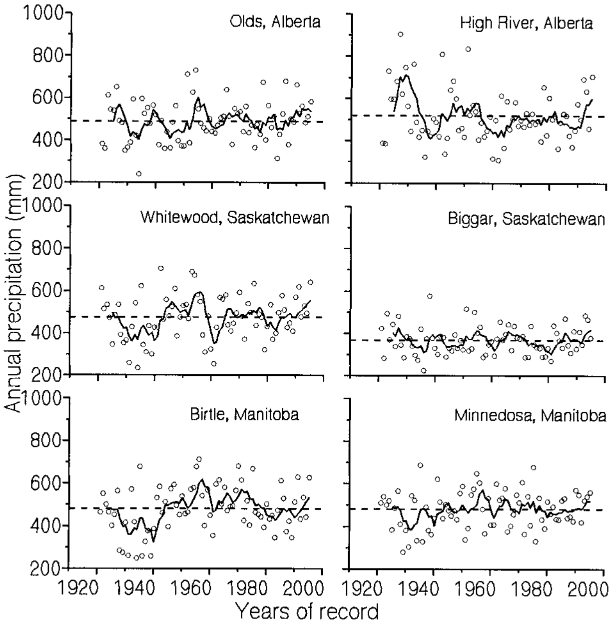

FIG. 1. Annual amount of precipitation and 5-yr running mean at six stations with 75 yr of records, with two stations from each of the three prairie provinces, Alberta, Saskatchewan, and Manitoba. The dashed horizontal line is the 75-yr mean.

From the plots of precipitation amounts (Fig. 1), the following points can be made: 1) there was no discernible trend in the amounts of precipitation as the running mean was close to the long-term mean, especially within the last 35 yr; 2) there was an apparent reduction in the amplitude of oscillation of the running mean after 1960, an indication of reduced variability. For selected stations on the Canadian prairies with 75 yr of recorded weather data, there was a positive trend in the number of precipitation events at several stations and no recognizable trend at others (Fig. 2).

c. *Linear trends in precipitation*

The slopes of the regression analysis for the amount of precipitation and the number of precipitation events, averaged across the prairies, are shown in Table 3. The trend in precipitation amount was positive at 30 stations and significantly greater than zero ($P \leq 0.05$) at nine stations. The trends at the seven remaining stations were negative and significantly less than zero at two stations. A trend of 0.62 mm yr^{-1} was obtained for the prairies (Table 3), which was significantly different from zero ($P \leq 0.05$), suggesting that precipitation has increased by 0.62 mm yr^{-1} during the last 75 yr. Groisman and Easterling (1994) reported a linear trend in total precipitation of 0.658 mm yr^{-1} for the zone 45°–55°N, which encompasses the region we analyzed in this study. Using a separate dataset, Groisman and Easterling (1994) reported a linear trend of 1.28 mm yr^{-1} for south-

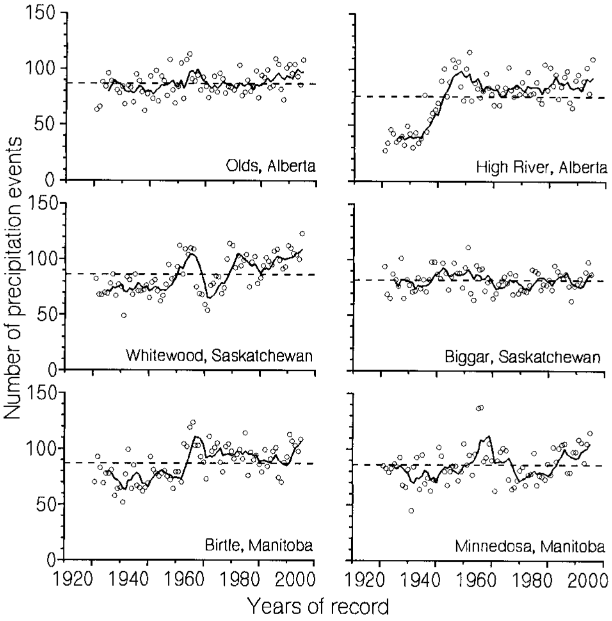

FIG. 2. Annual number of precipitation events and 5-yr running mean at six stations with 75 yr of records, with two stations from each of the three prairie provinces, Alberta, Saskatchewan, and Manitoba. The dashed horizontal line is the 75-yr mean.

ern Canada, which was twice the value we obtained in this study. The larger area included in the study of Groisman and Easterling, and the incomplete correction for the change in rain gauge as pointed out by Metcalfe et al. (1997), could have resulted in the larger precipitation trend of 1.28 mm yr^{-1}.

For the number of precipitation events (Fig. 3b), 22 stations had positive trends while one station had negative trends, which were significantly different from zero; trends were not significant at the 14 remaining stations. Concurrent with the increase in precipitation amounts was the increase in the number of precipitation events on the prairies. For the entire prairies, a trend of 0.21 events yr^{-1} was obtained, which was significantly different from zero ($P \leq 0.0001$). Similar to results at individual stations (Table 2), the low-intensity class (class 2) had a significant positive trend while the high-intensity class (Class 5) had a significant negative trend. Most of the trend in the total number of precipitation events is accounted for by the increase in the number of small events (class 2). Mekis and Hogg (1997) reported that the proportion of rainfall in events exceeding 25 mm has decreased between 1910 and the present at the majority of stations included in their analysis. This is similar to the significant negative trend obtained for class 5 on the Canadian prairies in our analysis.

The trend in the variance of precipitation (results not shown) was negative and significantly different from zero only at four stations. There was a negative trend at 23 stations and a positive trend at 10, but none of these was significant. Although the running mean suggested a reduction in variability (Fig. 2) and trend analysis showed negative trends of the variance at most stations, these trends were not large enough to be significant. The high variability of precipitation made the detection of a trend in its variance difficult.

TABLE 3. Linear trends of precipitation events across the prairies. Total precipitation, rainfall, and snowfall. Numbers in boldface type are significantly different from zero at the 0.05 level.

Parameters	Precipitation	Rainfall	Snowfall
Amount	0.62	0.60	0.01
Variance	−368.7	−277.5	−33.2
Class 2*	**0.203**	**0.158**	0.034
Class 3	0.010	**0.024**	0.039
Class 4	0.009	**0.015**	**−0.011**
Class 5	**−0.008**	−0.005	**−0.003**
Class 6	**0.214**	**0.193**	0.059

* Number of precipitation events in the range of 0.5–5, 5–10, 10–25, and >25 mm. Class 6 is the sum of classes 2–5.

d. Linear trends in rainfall and snowfall

There was a positive trend in the amount of rainfall at 32 stations (Fig. 4a), of which eight were significantly

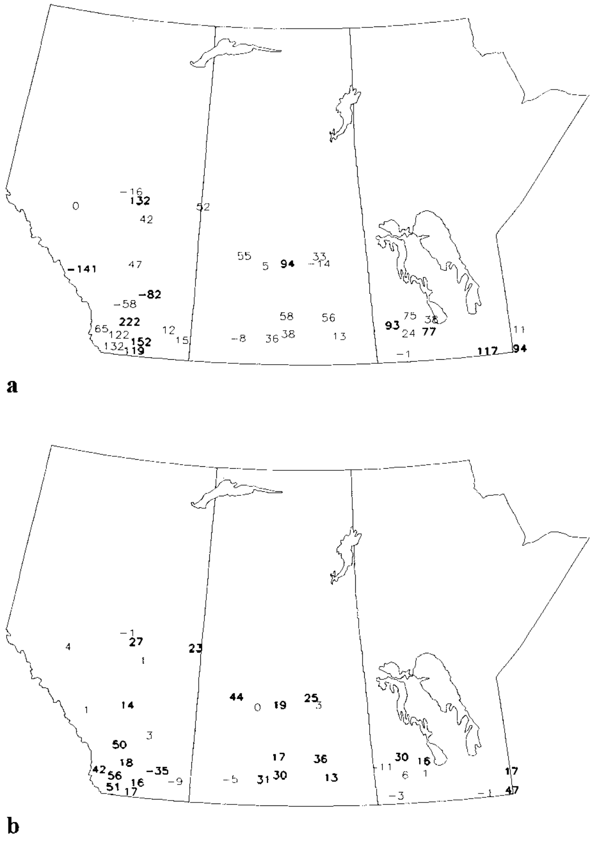

FIG. 3. The change in precipitation across the prairies during the most recent 75 yr: (a) amount of precipitation and (b) number of precipitation events. Numbers in boldface type represent slopes that are significantly different from zero at 95% confidence level.

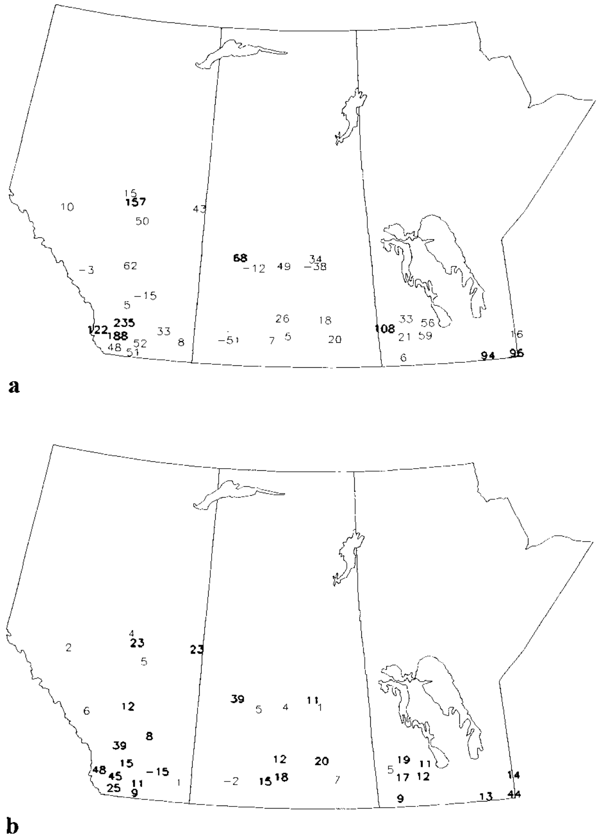

FIG. 4. The change in rainfall across the prairies during the most recent 75 yr: (a) amount of rainfall and (b) number of rainfall events. Numbers in boldface type represent slopes that are significantly different from zero at 95% confidence level.

different from zero. Five stations had negative trends but none of these was significant. Across the prairies, there was a positive trend of 0.60 mm yr^{-1} ($P \leq 0.05$), similar in magnitude to the trend in precipitation (Table 3) as a result of a negligible trend in the snowfall amounts. Of the 37 stations analyzed, 35 had a positive trend in the number of rainfall events, with significant trends at 25 stations. Only two stations showed negative trends, one of which was significant. The trend in the number of rainfall events of 0.19 per year was significant and of similar magnitude to that obtained for precipitation. In contrast to precipitation across the prairies, the trend in rainfall variance was significant at −277 mm^2 yr^{-1} (Table 3). These results suggest that across the prairies there has been an increase in rainfall amount, an increase in the number of events, and a decrease in the variance of rainfall within the last 75 yr.

None of the trends of snowfall was statistically significant and, therefore, spatial distributions were not presented. By splitting precipitation into rainfall and snowfall, we found that most of the trend in precipitation was due to rainfall. There was a noticeable inverse relationship between rainfall and snowfall trends at several stations, and a significant positive trend in rainfall amount was sometimes accompanied by a significant negative trend in snowfall, which reduced the trend in precipitation. Thus, while precipitation has been increasing on the prairies, this increase was due to increases in rainfall amounts. An overall trend of 0.01 mm yr^{-1} across the prairie, which is similar to the trend of −0.18 mm yr^{-1} (−0.18 cm of snow, assuming a 10:1 ratio) reported by Groisman and Easterling (1994) for the zone 45°–55°N.

e. Comparison of trends between two periods

The 75 yr of record were split into two periods: period 1 was from 1921 to 1960 and period 2 was from 1961 to 1995. These two time series were analyzed for trends using the approach of Idso and Balling (1991). Our hypothesis was if there is a trend in a climatic parameter resulting from the intensification of industrialization and fossil fuel emissions, the trend should be larger in the more recent of the two periods as the effect of industrialization and fossil fuel consumption will be additive in time.

The analyses showed that from 1921 to 1960 (period 1) the trends in precipitation, rainfall, and snowfall amount were not statistically different from zero (Table 4). From 1961 to 1995 (period 2), rainfall increased by 1.32 mm yr^{-1}, which was double the trend in the previous 40 yr; but neither of these trends was significantly different from zero and hence not statistically different from each other. For snow, on the other hand, a significant decrease of 0.95 mm yr^{-1} was obtained during the most recent 35 yr. The trend in period 2 was also significantly different from that in period 1 for the snowfall amount. The opposite sign of the trends in rainfall and snowfall resulted in a reduced and nonsignificant trend in precipitation during the most recent period. The results demonstrated that there has been a significant decrease in snowfall amount within the last 35 yr across the prairies; while rainfall has increased during this period, this was not significant. It is difficult to attribute these trends directly to climate change; the pattern, however, coincides with model predictions made from global warming simulations. Saunders and Byrne (1994) analyzed the output from the Canadian Climate Centre GCM for the prairies and concluded that less snow will fall on the prairies in a 2× CO_2 world.

The trend in the number of events was significantly different from zero during both periods for rainfall and total precipitation, but not for snow. While the trend in the number of rainfall events was higher in period 2, it was not statistically different from the value obtained in period 1. For snowfall, the trend in the number of events during period 2 was negative; however, this was not significantly different from the value obtained in period 1.

TABLE 4. Statistics of precipitation trends across the prairies for the two periods 1921–60 and 1961–95.

	1921–60		1961–95		
Parameter	Slope*	Confidence interval	Slope	Confidence interval	*t***
Precipitation (rainfall + snowfall)					
Amount (mm yr^{-1})	1.19	±1.66	0.37	±1.61	0.70
Number (yr^{-1})	**0.31**	±0.18	**0.32**	±0.20	0.10
Rainfall					
Amount (mm yr^{-1})	0.61	±1.37	1.32	±1.48	0.70
Number (yr^{-1})	**0.21**	±0.13	**0.37**	±0.17	1.50
Snowfall					
Amount (mm yr^{-1})	0.58	±0.73	**−0.95**	±0.86	**2.74**
Number (yr^{-1})	0.23	±0.28	0.14	±0.33	1.75

* Slopes in boldface type are significantly different from zero at the 0.95 confidence level.

** *t* statistics in boldface type indicate a statistically significant difference between 1921–60 and 1961–95 trends at the 0.95 confidence level.

f. Trends of precipitation during the last 21 yr

Instability of precipitation classes is possible due to the correction for inhomogeneity in rainfall. To confirm the stability of precipitation trends, we analyzed the most recent 21 yr of record (1975–95) when no correction factor was applied and measurements are known to be homogeneous. We wanted to determine if the trends in the rainfall classes shown in Tables 3 and 4 were due to the correction factor applied to rainfall amounts up to 1974.

The trend in the number of rainfall events during the last 21 yr was 0.41 (Table 5), which is higher than the 0.19 obtained for the 75-yr time series (Table 3) but similar to the 0.37 obtained for the most recent 35 yr (Table 4). The trends in precipitation and rainfall amounts, 1.9 and 2.3 mm, respectively, are also higher for the most recent 21 yr compared to the 75-yr time series (0.62 and 0.6 mm, respectively). However, unlike the rainfall events, the trends in precipitation and rainfall amount for the most recent 21 yr were not significantly different from zero. The similarity of the trend in the number of rainfall events between the last 21 yr, a period without rainfall correction, and the last 35 yr, which included correction for rainfall inhomogeneity, increased our confidence in the trends obtained in this study.

TABLE 5. Linear trends of precipitation characteristics across the prairies during the last 21 yr (1975–95).

Parameters	Precipitation	Rainfall	Snowfall
Amount	*1.93	2.31	−0.38
Class 2**	**0.48**	**0.34**	0.08
Class 3	−0.05	0.02	0.07
Class 4	−0.008	0.03	**−0.05**
Class 5	0.013	0.02	−0.004
Class 6	0.43	**0.41**	0.096

* Numbers in boldface type are significantly different from zero.

** Number of precipitation events in the range of 0.5–5, 5–10, 10–25, and >25 mm. Class 6 is the sum of classes 2–5.

g. Possible causes of trends in number and amounts of precipitation

The determination of the causes of measured trends in precipitation amounts and number of events is beyond the scope of this study; nevertheless, several possibilities are speculated. The small increase in the amount of precipitation on the Canadian prairies is internally consistent with the large increase in the number of low-intensity events found in this study. If the intensification hypothesis, that is, a significant increase in the number of high-intensity events, is to hold on the Canadian prairies, the total amount of precipitation will have to increase by a large amount. If the total amount of precipitation remains unchanged following an increase in the number of high-intensity events, then a large decrease is expected in the number of small events to compensate for the increase in intensity, as dictated by the characteristics of precipitation on the prairies. This was not borne out by the results of our analysis.

The beginning of our time series (1921–95) coincided with a large-scale rainfall anomaly on the prairies referred to as the dust bowl (1929–38). The occurrence of this phenomenon during the period of analysis partly contributed to the trend measured in this period. Low temperatures during the prairie winter are responsible for precipitation in the form of snow. In a warmer climate, especially during the spring and fall seasons, more of the precipitation will come as rain with a concomitant decrease in the amount of snowfall. A warming trend on the prairie may partly explain the negative snowfall and positive rainfall trends obtained in this study.

4. Conclusions

There has been a significant increase in the number of precipitation events on the Canadian prairies. This increase in the number of precipitation events is mainly due to an increase in the number of low-intensity events. It follows that precipitation events do not appear to be getting more intense on the Canadian prairies. There has been a significant increase in the amount of precipitation on the Canadian prairies during the last 75 yr. This increase in precipitation is mainly due to an increase in the amounts of rainfall. The difference in trends between the two periods in this study for snowfall, combined with the inverse relationship in the rainfall–snowfall trends, suggest that these may be climate-change related.

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