

# Temperature and precipitation trends in southwestern Saskatchewan tell a complex long-term climate change story

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## Abstract

Historical climate trends in southwestern Saskatchewan, Canada were analyzed using parametric linear regression and non-parametric Mann-Kendall trend detection approaches over various timeframes between 1886 and 2010. We find substantial variability for this region in the significance and magnitude of any temporal trends for daily maximum, minimum, and mean temperatures on an annual basis - as well as during the winter, spring, summer, and autumn periods - that is dependent on the time period chosen. Similar results are obtained for precipitation data in the study area. The results demonstrate that temperature and precipitation trends in southwestern Saskatchewan tell a complex long-term climate change story, containing substantial temporal trend heterogeneity, thereby necessitating caution when interpreting long-term climatic data - particularly in the context of larger-scale regional or global observations and predictions.

### Keywords:

Climate change, Saskatchewan, Temporal trend variability, Temperature, Precipitation

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Historical climate trends for southwestern Saskatchewan, Canada are of interest because of their impacts on agricultural activities in this region [1, 2], as well as for ground-truthing global climate models and associated down-scaling efforts. Recent work concluded that warming trends in southwestern Saskatchewan between 1950 and 2007 were equivalent to those observed between 1950 and 1997, suggesting that the period between 1997 and 2007 simply extended the same rate of temperature increase found during the prior five decades [3]. In the current work, we demonstrate that temperature trends in southwestern Saskatchewan tell a complex long-term climate change story, containing substantial temporal trend heterogeneity.

Climate data was obtained from the second generation suite of Adjusted and Homogenized Canadian Climate Data (AHCCD; <http://ec.gc.ca/dccha-ahccd/>) [4, 5]. The AHCCD contains the following three climate stations in southwestern Saskatchewan (Figure 1 and Table 1): Aneroid (ID 4020160), Swift Current (ID 4028040 [temperature]/60 [precipitation]), and Val Marie (ID 4038400). Both the Aneroid and Val Marie climate records contain a significant number of gaps that preclude reliable trend analyses. The Swift Current temperature record contains a complete annual time series between 1886 and 2010 with the exception of 1979 and 2007, having corresponding gaps during 1979 for the autumn period and 2007 for the sum-

Table 1: Summary details for the climate monitoring stations in southwestern Saskatchewan, Canada.

Station Name	Aneroid	Swift Current	Val Marie
ID	4020160	4028040/60	4038400
Record length	1922-2005	1885-2011	1937-2010
Latitude (deg)	49.72	50.27	49.37
Longitude (deg)	-107.30	-107.73	-107.85
Elevation (m)	754	817/825	808
Stations joined?	No	Yes	No

mer period, and a complete time series absent gaps for the winter and spring periods. The Swift Current precipitation record contains data gaps during 1938, 1939, and 1992. For continuous and discontinuous time series, trends were investigated using parametric linear regression (KypPlot v.2.0b15). For continuous time series (i.e., winter and spring period temperatures), trends were also examined using the non-parametric Mann-Kendall method with the Sen's slope [6-8] within the R statistical software package [9].

We find significant variability in the significance and magnitude of any temporal trends for daily maximum, minimum, and mean temperatures on an annual basis, as well as during the winter, spring, summer, and autumn periods, over various timeframes between 1886 and 2010 for the Swift Current climate station (Table 2). Good agreement was observed for the trend significance and magnitude between the parametric linear regression and the non-

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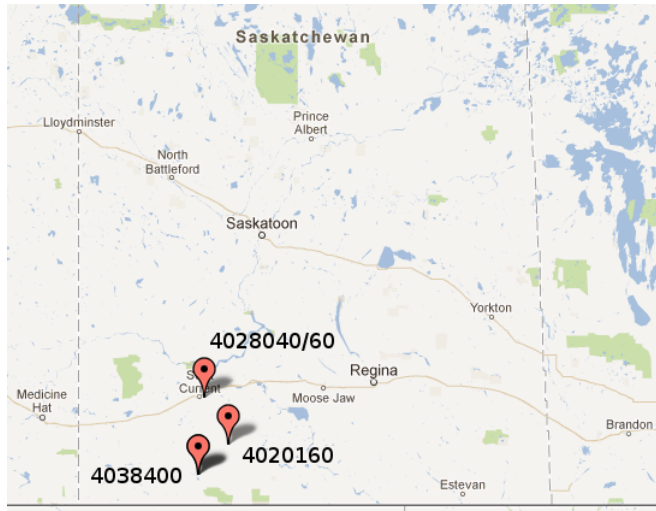


Figure 1: Locations of the climate monitoring stations in southwestern Saskatchewan, Canada.

parametric Mann-Kendall/Sen’s analytical approaches.

It is important to note that a generally high degree of non-significance (i.e., p-values up to and exceeding 0.9) was found for the temperature trends over the past several decades, indicating that any longer-term trends with significance (e.g., the 1950-2010 period) are being driven by the pre-1970 period. Overall, there appears to be little evidence of changing temperatures in southwestern Saskatchewan since the 1990s. We find similar results for the precipitation record at Swift Current (Table 3). No consistent statistically significant trends were found across the various time periods for total precipitation, rainfall, or snowfall. In general, there is no clear evidence of any trends in precipitation in southwestern Saskatchewan.

In conclusion, historical temperature and precipitation trends for southwestern Saskatchewan vary widely by the timeframe chosen for analysis, necessitating caution when interpreting long-term climatic data - particularly in the context of larger-scale regional or global observations and predictions.

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Table 2: Trends in daily maximum, minimum, and mean temperatures on an annual basis, as well as during the winter, spring, summer, and autumn periods, over various timeframes between 1886 and 2010 for the Swift Current climate station (ID 4028040). Data presented as annual trend ( $^{\circ}\text{C}/\text{year}$ ) and corresponding level of significance (NS= $p>0.1$ ; += $0.05<p\leq 0.1$ ; \*= $0.01<p\leq 0.05$ ; \*\*= $0.001<p\leq 0.01$ ; and \*\*\*= $p\leq 0.001$ ).

Timeframe	Annual	Winter	Spring	Summer	Autumn
<b>Daily maximum temperature</b>					
1886-2010					
Parametric	0.0080/*	0.019/*	0.011/+	NS	NS
Mann-Kendall	n/a <sup>a</sup>	0.020/**	0.013/*	n/a	n/a
1920-2010					
Parametric	NS	NS	0.015/+	-0.011/+	NS
Mann-Kendall	n/a	NS	0.017/+	n/a	n/a
1950-2010					
Parametric	0.032/**	0.048/*	0.063/**	NS	NS
Mann-Kendall	n/a	0.040/*	0.064/**	n/a	n/a
1970-2010					
Parametric	NS	NS	NS	NS	0.046/+
Mann-Kendall	n/a	NS	NS	n/a	n/a
1990-2010					
Parametric	NS	NS	NS	NS	NS
Mann-Kendall	n/a	NS	NS	n/a	n/a
<b>Daily minimum temperature</b>					
1886-2010					
Parametric	0.015/**	0.026/**	0.014/**	0.0082/**	0.010/**
Mann-Kendall	n/a	0.025/**	0.016/**	n/a	n/a
1920-2010					
Parametric	0.013/**	0.027/*	0.013/*	0.0055/+	NS
Mann-Kendall	n/a	0.029/*	0.015/**	n/a	n/a
1950-2010					
Parametric	0.030/**	0.060/**	0.042/**	0.012/*	NS
Mann-Kendall	n/a	0.057/*	0.045/**	n/a	n/a
1970-2010					
Parametric	0.044/**	0.074/+	NS	0.019/+	0.060/**
Mann-Kendall	n/a	0.064/+	0.038/+	n/a	n/a
1990-2010					
Parametric	NS	NS	NS	NS	0.089/+
Mann-Kendall	n/a	NS	NS	n/a	n/a
<b>Daily mean temperature</b>					
1886-2010					
Parametric	0.011/**	0.022/**	0.013/**	NS	NS
Mann-Kendall	n/a	0.022/**	0.015/**	n/a	n/a
1920-2010					
Parametric	0.0080/+	NS	0.014/+	NS	NS
Mann-Kendall	n/a	0.021/+	0.017/*	n/a	n/a
1950-2010					
Parametric	0.031/**	0.053/*	0.053/**	NS	NS
Mann-Kendall	n/a	0.047/*	0.054/**	n/a	n/a
1970-2010					
Parametric	0.034/*	NS	NS	NS	0.053/*
Mann-Kendall	n/a	NS	NS	n/a	n/a
1990-2010					
Parametric	NS	NS	NS	NS	NS
Mann-Kendall	n/a	NS	NS	n/a	n/a

<sup>a</sup> not applicable.

Table 3: Trends in total precipitation, rainfall, and snowfall on an annual basis, as well as during the winter, spring, summer, and autumn periods, over various timeframes between 1886 and 2005/2006 for the Swift Current climate station (ID 4028060). Data presented as annual trend (mm/year) and corresponding level of significance (NS= $p > 0.1$ ;  $+ = 0.05 < p \leq 0.1$ ;  $* = 0.01 < p \leq 0.05$ ;  $** = 0.001 < p \leq 0.01$ ; and  $*** = p \leq 0.001$ ).

Timeframe	Annual	Winter	Spring	Summer	Autumn
<b>Total precipitation</b>					
1886-2005	-0.44/+	NS	NS	NS	NS
1920-2005	NS	NS	NS	NS	NS
1950-2005	NS	NS	NS	NS	NS
1970-2005	NS	NS	NS	NS	NS
1990-2005	NS	NS	NS	NS	NS
<b>Rainfall</b>					
1886-2006	NS	0.027/***	NS	NS	NS
1920-2006	NS	0.023/+	NS	NS	NS
1950-2006	NS	0.043/+	NS	NS	NS
1970-2006	2.4/*	NS	NS	NS	0.91/*
1990-2006	NS	NS	NS	NS	NS
<b>Snowfall</b>					
1886-2005	NS	NS	NS	n/a <sup>a</sup>	NS
1920-2005	NS	NS	NS	n/a	NS
1950-2005	-0.52/+	-0.28/+	NS	n/a	NS
1970-2005	NS	NS	NS	n/a	NS
1990-2005	NS	NS	NS	n/a	NS

<sup>a</sup> not applicable.