Trends in indices related to agroclimatic conditions based on homogenized temperature and adjusted precipitation in Canada

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Introduction

The recently updated homogenized daily minimum and maximum surface temperatures and adjusted daily rainfall and snowfall observations are used to assess long-term trends in a few indices related to agriculture. The datasets can be found at:

http://www.ec.gc.ca/dccha-ahccd.

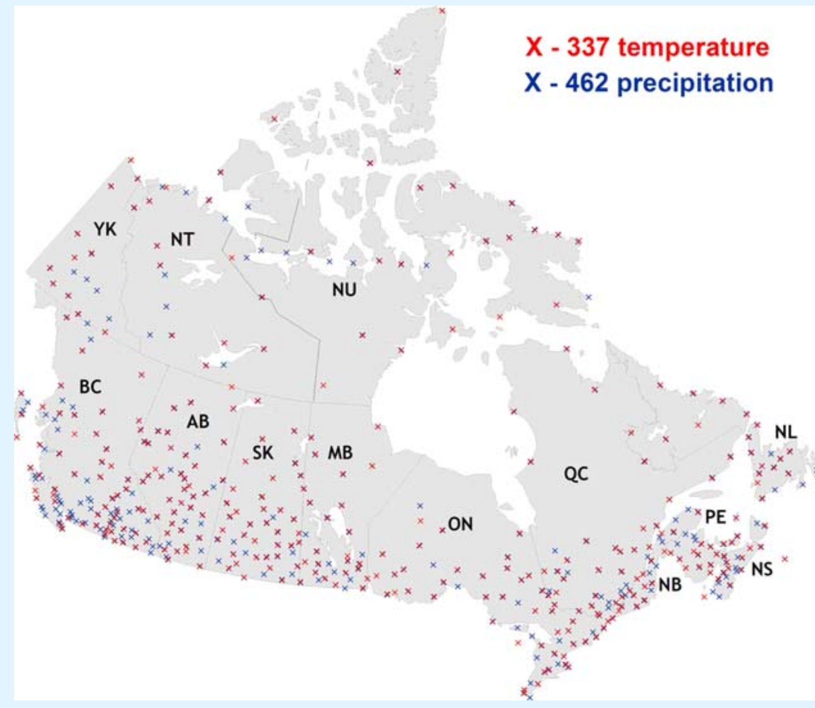

Figure 1: Location of the 337 homogenized temperature and the 464 adjusted precipitation stations across Canada.

Temperature and Precipitation Data

The Second Generation of Homogenized Temperature for Canada provides homogenized daily minimum and maximum temperature for 337 stations across the country. Adjustments were first applied to address the bias due to the change in observing time at airport stations in 1961 (Vincent et al. 2009). Observations from nearby stations were sometimes combined to create long time series that are useful for climate change studies. Non-climatic shifts were identified using techniques based on regression models (Vincent, 1998; Wang et al. 2007) and a new procedure based on quantile matching algorithm was applied to derive daily adjustments (Wang et al. 2007).

The Second Generation Adjusted Precipitation for Canada provides adjusted daily rainfall, snowfall and total precipitation for over 450 locations. The methods to adjust daily rainfall and snowfall are described in Mekis and Vincent (2011). For each rain gauge type, corrections to account for wind undercatch, evaporation, and gauge specific wetting losses were implemented (Devine and Mekis, 2008). For snowfall, density corrections based upon coincident ruler and Nipher measurements were applied to all snow ruler measurements (Mekis and Brown, 2010). The trace precipitation have also been adjusted (Mekis, 2005; Mekis and Vincent, 2011). The accumulated rain or snow amounts were distributed over the affected days in order to minimize the impact on extreme values. Adjustments obtained from standardized ratios between the tested site and neighbours or overlapping observations were applied for the joining of observations (Vincent and Mekis, 2009).

Indices and trend computation

This preliminary study presents the trends in 6 indices related to agroclimatic conditions in Canada (Table 1). Temperature trends are examined for Growing Degree-Days (GDD), length of Growing Season (GS) and Frost-Free Season (FFS). After examining trends in annual total Precipitation amount (P), the frequency and distribution changes are assessed by examining the Number of Days with Precipitation (NDP) and the Maximum number of Consecutive Dry Days (MCDD). The trends in indices are presented for both periods 1900-2010 and 1950-2010. The long period describes the conditions found mainly in Southern Canada, since many Canadian stations in the north were established in the early 1950s.

The non-parametric Kendall's test was used to estimate the slope of the trend at any individual station. The 3/5 rule was applied for both temperature and precipitation indices: in any month, if more than 3 consecutive days or more than 5 random days are missing, then the month is missing. For each station, the trends were computed for the periods 1950-2010 and 1900-2010 only if more than 80% of the values were present.

	Indices	Description	Unit	1900-2010					1950-2010				
				-	ns	+	tot	%	-	ns	+	tot	%
Temperature	Growing Season (GS)	Start when $t_{mean} \geq 5$°C for 5d & end when $t_{mean} < 5$°C for 5d (Jan-Dec)	days	0	34	**38**	72	53	0	135	**60**	195	31
	Frost-Free Season (FFS)	Max # of consecutive days with tmin > 0°C (Jan-Dec)	days	2	26	**57**	85	67	3	142	**71**	216	33
	Growing Degree-Days (GDD)	Sum of degrees with $t_{mean} \geq 5$°C	°days	0	14	**58**	72	81	0	53	**142**	195	73
Precipitation	Annual total Precipitation (P)	Annual accumulated sum of daily rain and snow events	mm	1	40	**47**	88	53	5	170	**46**	221	21
	Number of Days with Precipitation (NDP)	Number of days with total precipitation ≥ 1 mm	days	2	45	**41**	88	47	12	156	**53**	221	24
	Maximum number of Consequtive Dry Days (MCDD)	Maximum number of consecutive dry days (trace excluded)	days	**25**	61	2	88	28	17	202	2	221	8

Table 1: Number of stations with significant negative, not significant and positive trends for 3 temperature and 3 precipitation indices over 1900-2010 and 1950-2010 respectively. The number in bold indicates that more than 20% of the stations have a significant trend (significant at 5% level).

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Preliminary results

Temperature Trends

1900-2010 1950-2010

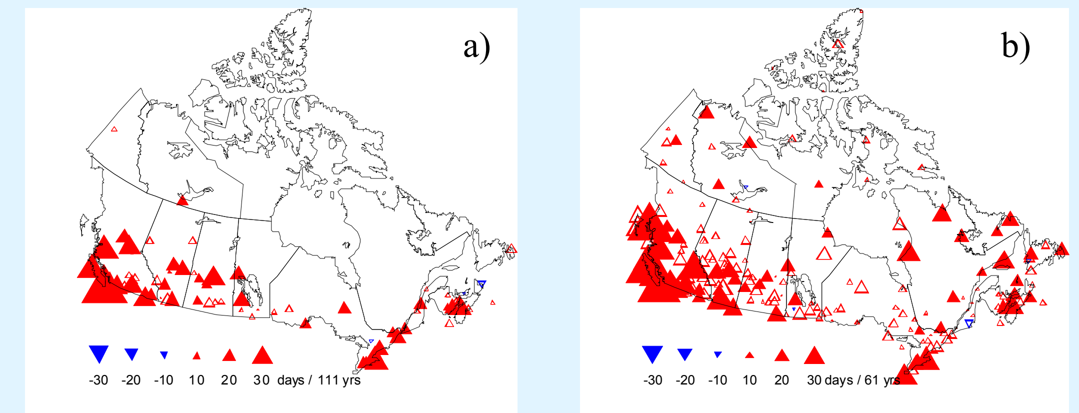

Figure 2: Trends in length of growing season

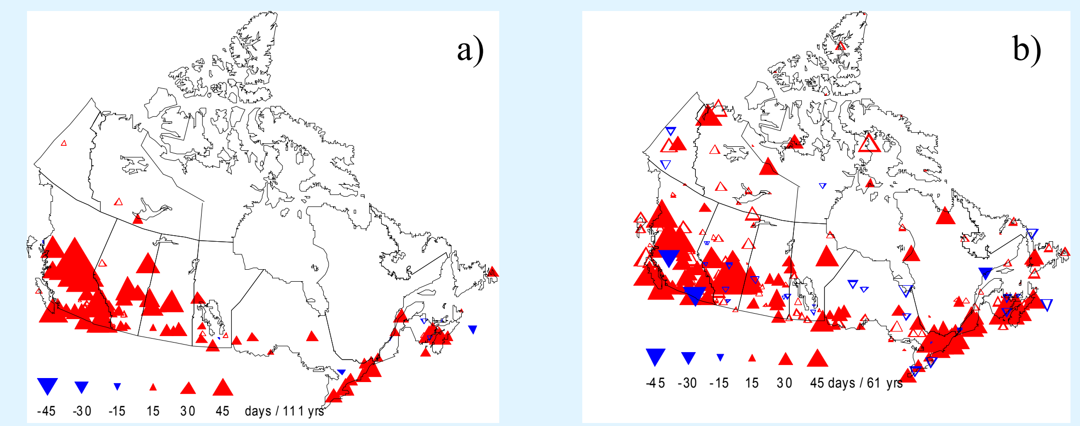

Figure 3: Trends in length frost-free season

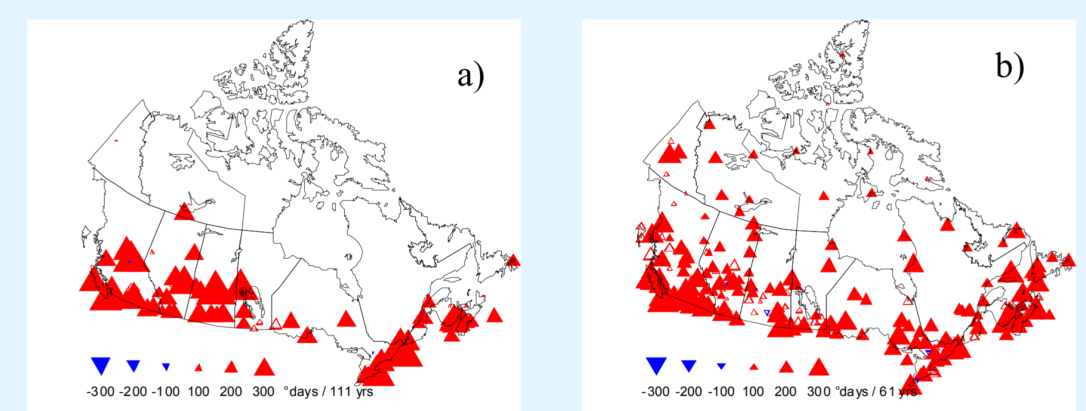

Figure 4: Trends in growing degree-days

Precipitation Trends

1900-2010 1950-2010

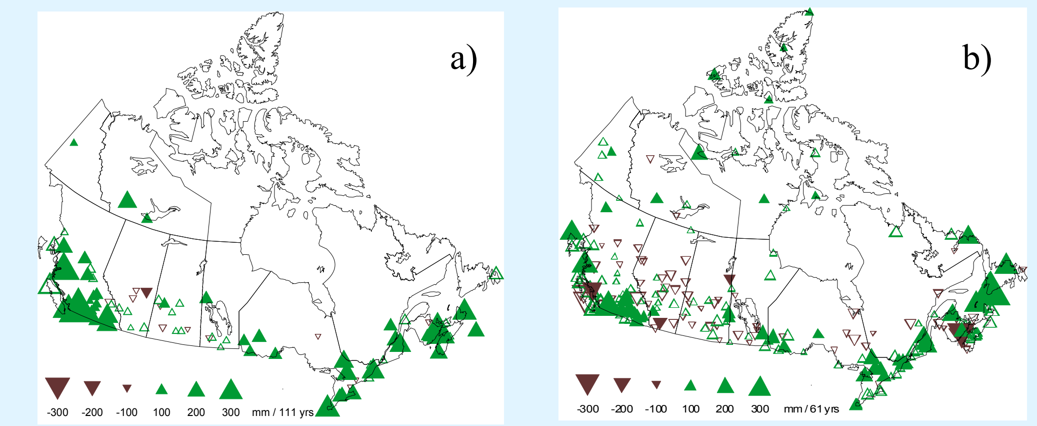

Figure 5: Trends in annual total precipitation

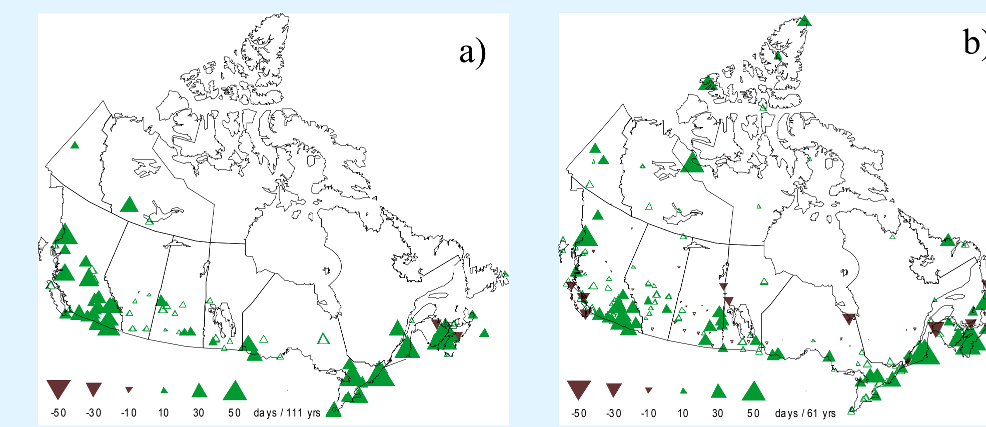

Figure 6: Trends in number of days with ≥ 1 mm precipitation

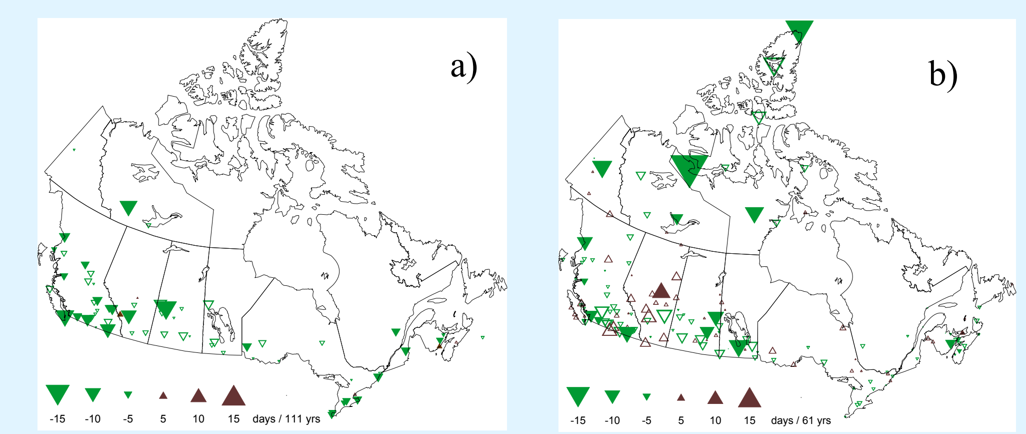

Figure 7: Trends in the maximum consequtive dry days

Trends in temperature, 1900 – 2010

The results indicate that the length of growing season (GS) has increased over 1900-2010 (Fig. 2a): 53% of the stations show a significant increasing trend in their GS. The magnitude of the trends varies from one location to another, but increasing trends are observed across the whole country. The frost-free season (FFS) has also increased at most stations (Fig. 3a) and the trends were significant at 67% of the stations. The increase in length of growing degree-days (GDD) (Fig. 4a) can be associated both to the temperature increase during the GS and lengthening of GS: the increasing significant trend observed at as many as 81% of the stations suggests the cumulative effect of both increases.

Trends in temperature, 1950 – 2010

The trends pattern is similar for the shorter period of time as for the longer period 1900-2010. Significantly increasing trends were observed in the length of the GS in 31% of stations (Fig. 2b) and 33% of stations for FFS (Fig. 3b). The strongest signal is in the GDD showing increasing trend at 73% of stations (Fig 4b), which is in agreement with Qian et al, 2009.

Trends in precipitation, 1900 – 2010

The change in the available precipitation (P) amount is an important indicator of the agroclimatic conditions. In the Prairies, only one station showed significant decreasing P trend surrounded by a few not significant decreasing trends (Fig. 5a). The rest of the country (53% of all stations) shows significant increasing trend. Regarding the distribution of the P events, the number of days with precipitation (NDP) is significantly increasing at 47% of the locations (Fig. 6a) and number of maximum consecutive dry days (MCDD) is significantly decreasing at 28% of the stations (Fig 7a). Overall, the results show an increasing number of rainy days through most part of Canada.

Trends in precipitation, 1950 – 2010

For the past 61 years, 21% of the stations indicate significant increase in annual total precipitation (P) (Fig. 5b). However, in the Prairies, which is an important agriculture region in Canada, most stations show non-significant decreasing trend. For the NDP, the majority of the country is characterised by increasing trends with 24% of them being significant (Fig. 6b). The MCDD does not show an overall significant change: the Canadian Prairies shows a mix pattern of non-significant increasing in the west (drying) and non-significant decreasing trends in the east (Fig. 7c).

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