CHANGING SUMMER CLIMATE ON THE PRAIRIES: FROM DROUGHTS TO FLOODS – AN ASSESSMENT OF THE CAUSES AND CONSEQUENCES SINCE 1990

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INTRODUCTION

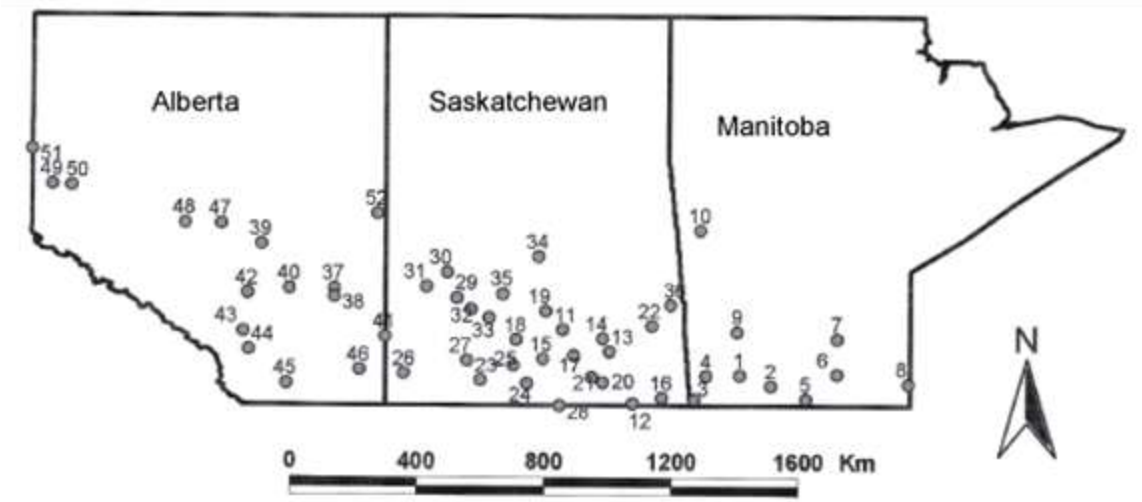
- The purpose of this talk is to present a preliminary assessment of the causes and consequences of extremely wet and dry May-Julys periods over the prairies since 1990 with special reference to 2010.

- Using rainfall data for the period 1950-2010 there have been six extremely wet (2010, 1991, 1999, 1993, 2005 and 2004) and two extremely dry (2009 and 2003) May-July periods since 1990.

- The summers of 2010, 1991, 1999, 1993, 2005, 2004, 2009 and 2003, are analyzed on a case-by-case basis in relation significant seasonal influences. Garnett et al. 2006 found that a combination of low (high) sunspot, a westerly (easterly) phase of the quasi-biennial wind oscillation, El Nino (La Nina) conditions and below (above) normal North American snow cover can act synergistically to produce a wet (dry) summers over the prairie region.

- Solar cycle 24 (2010-2021) will be compared and contrasted with the Dalton Minimum of 1795-1823.

STUDY AREA AND DATA SOURCES



MONTHLY DATA FOR THE PERIOD 1950-2004

Precipitation and temperature for 51 stations

Environment Canada

Precipitation 2005-2010 for 30 stations

Environment Canada

Sunspot

U.S. NOAA Geophysical Data Centre Boulder, Colorado.

30 hpa Quasi-Biennial Wind Oscillation (QBO)

U.S. Climate Prediction Centre

Nino 3 and Nino 3.4 sea surface temperatures

U.S. Climate Prediction Centre

North American snow (NAS) cover extent 1974-2004

U.S. Climate prediction Centre

PRECIPITATION AND TEMPERATURE OVER THE PRAIRIE REGION APRIL THROUGH SEPTEMBER OF 2010

Table 1.

	Precipitation (mm)			Temperature (ºC)		
	Actual	Normal	% of normal	Actual	Normal	DFN
April	54	27	200	6.4	3.6	+ 2.8
May	95	47	202	9.2	10.8	-1.6
June	102	74	138	15.2	15.4	-0.3
July	71	67	106	19.7	18.0	-0.6
August	74	55	134	16.7	17.0	-0.7
September	54	41	132	10.1	11.2	-1.1
Mean anomaly April-September			152			-0.25

Note: Precipitation and temperatures are based on 30 and 10 stations respectively
Normal amounts based on 100 stations for the period 1950-1995

WETTEST AND DRIEST MAY-JULYS FOR THE PERIOD 1950-2010
Extremely wet and dry years since 1990 highlighted

Table 2.

Wettest (mm/mo)		Driest (mm/mo)	
2010	88.3	1967	28.7
1991	85.5	1958	37.9
1999	84.4	1961	40.1
1993	82.5	1985	42.8
1953	82.1	2009	46.0
2005	81.0	1957	46.3
1986	77.3	2003	46.5
1977	77.1		
1963	76.8		
1965	76.7		
2004	76.1		

Mean 62.9 mm/mo 1 S.D. is 12.5 > 1 S.D 75.4 < 1 S.D 50.4

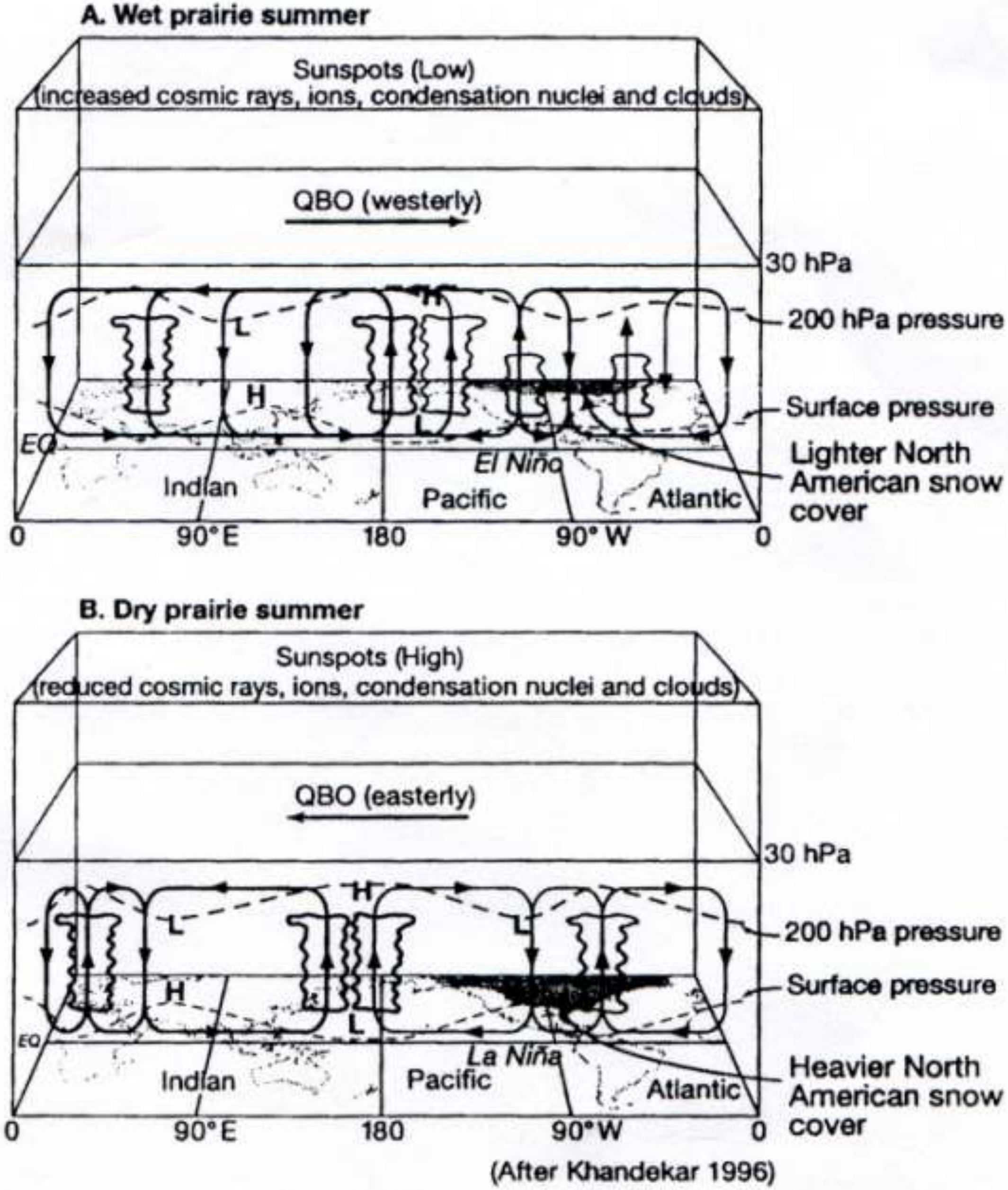
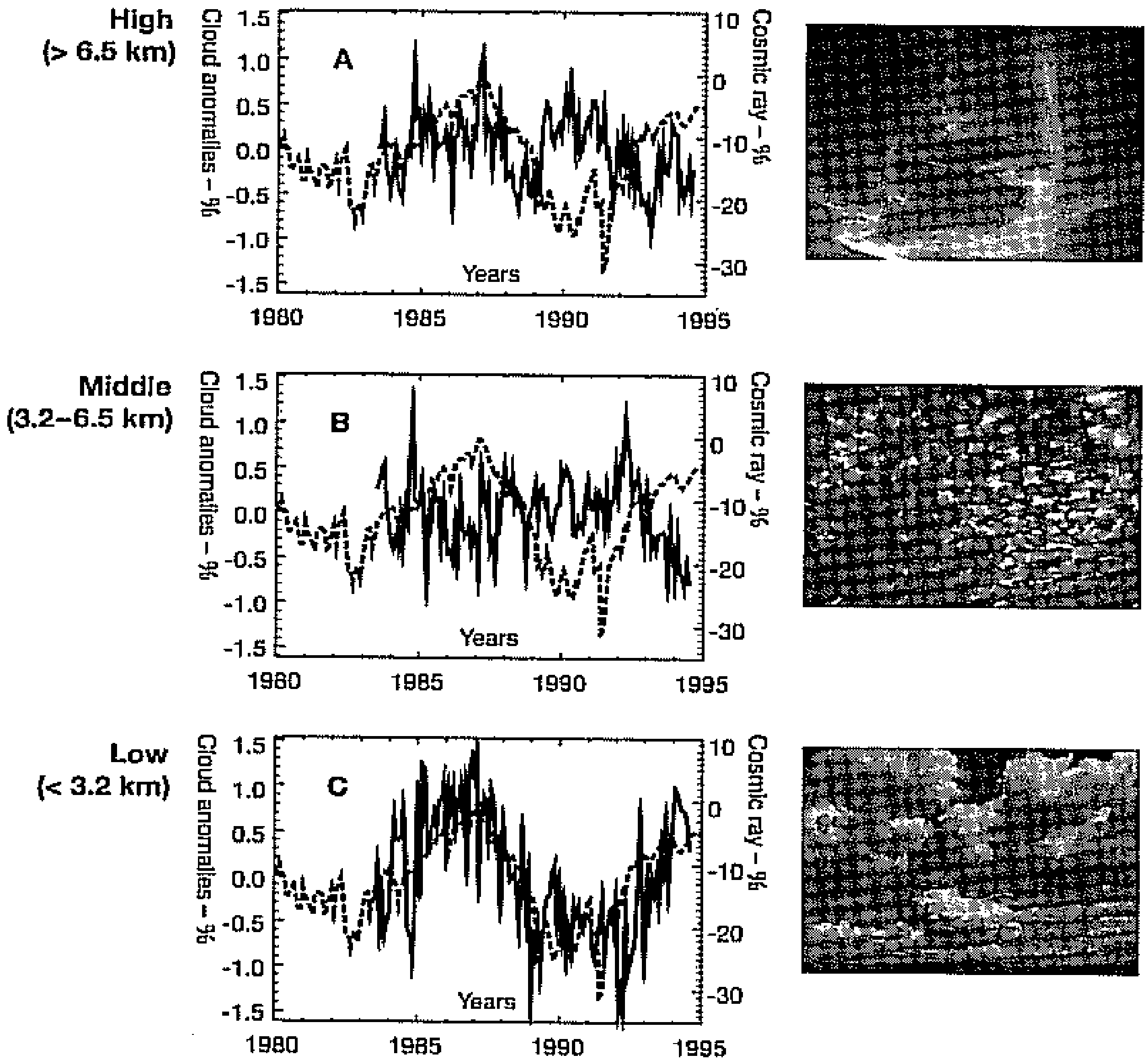
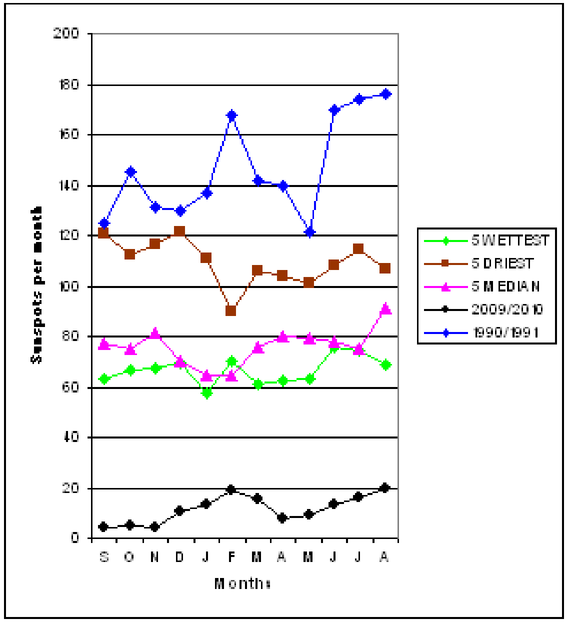


Fig. 2. Conceptual model of factor producing wet and dry prairie summers. H: high, L: low pressure system


High
(> 6.5 km)
Middle
(3.2–6.5 km)
Low
(< 3.2 km)
A
B
C
Cloud anomalies – %
Cosmic ray – %
Years
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
10
0
-10
-20
-30
1980
1985
1990
1995



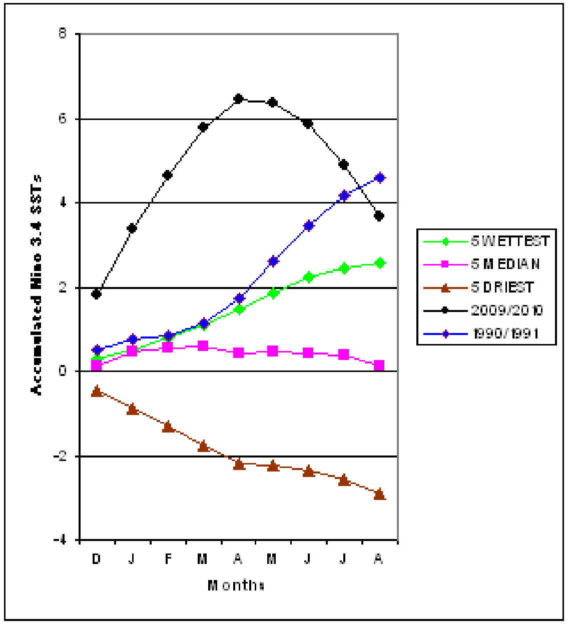


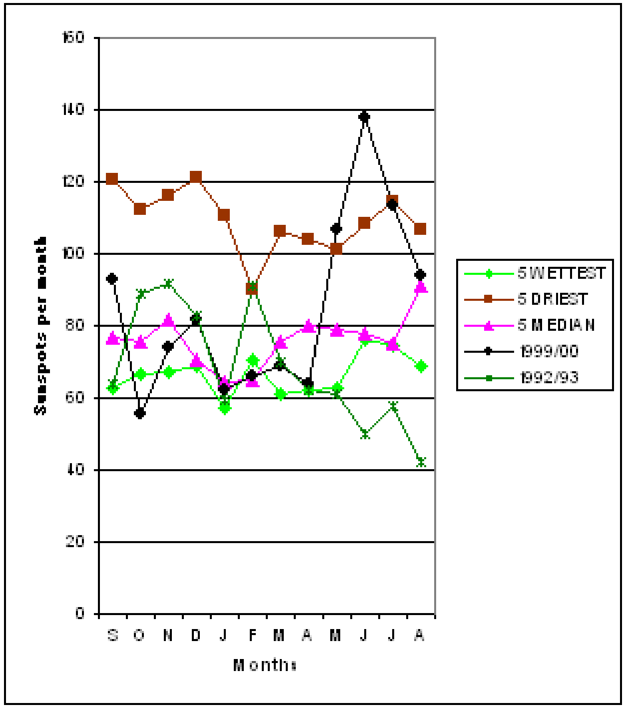
Fig. 1. Sunspots per month for two wettest May-Julys

Fig. 2. Accumulated Nino 3.4 sea surface temperatures before and during June-July of the two wettest May-Julys

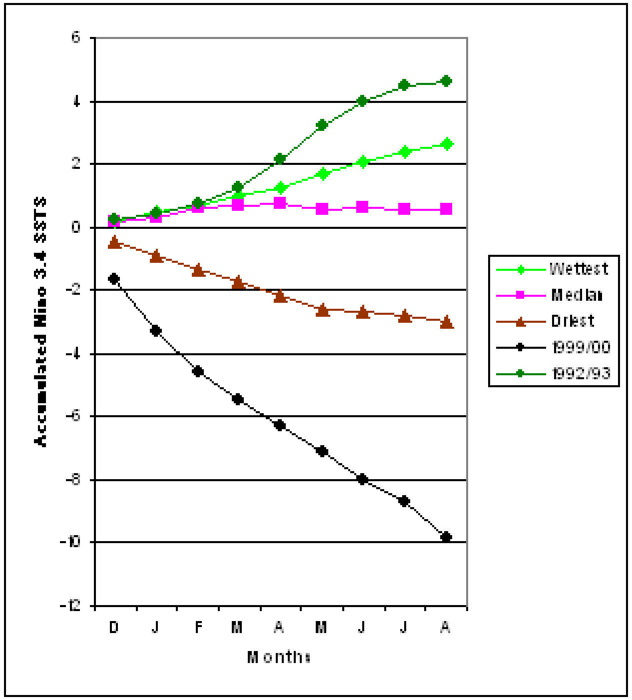
Working Hypothesis re: causes of two wettest May-Julys for the period 1990-2010

2010: Low sunspot activity, El Nino and below normal April NAS

1991: El Nino, westerly QBO, and below normal April NAS



Sunspots per month
160
140
120
100
80
60
40
20
0
S O N D J F M A M J J A
Months
5 WETTEST
5 DRIEST
5 MEDIAN
1999/00
1992/93



Accumulated Nino 3.4 SSTS
6
4
2
0
-2
-4
-6
-8
-10
-12
D J F M A M J J A
Months
Wettest
Median
Driest
1999/00
1992/93

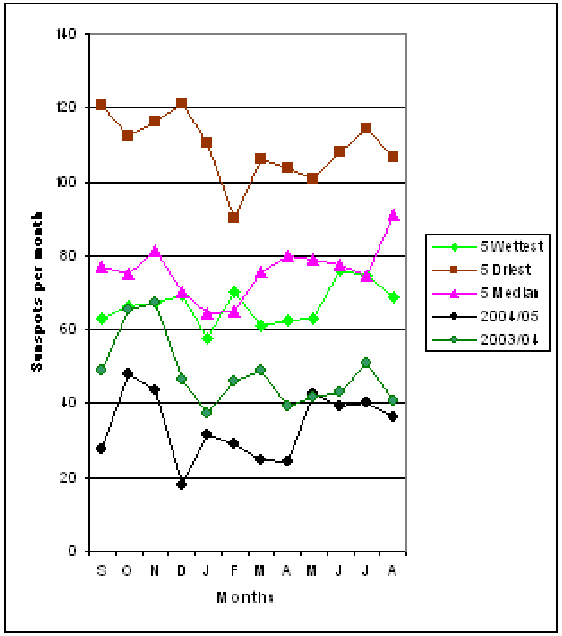


Fig. 5. Sunspots per month before and during fifth and sixth wettest

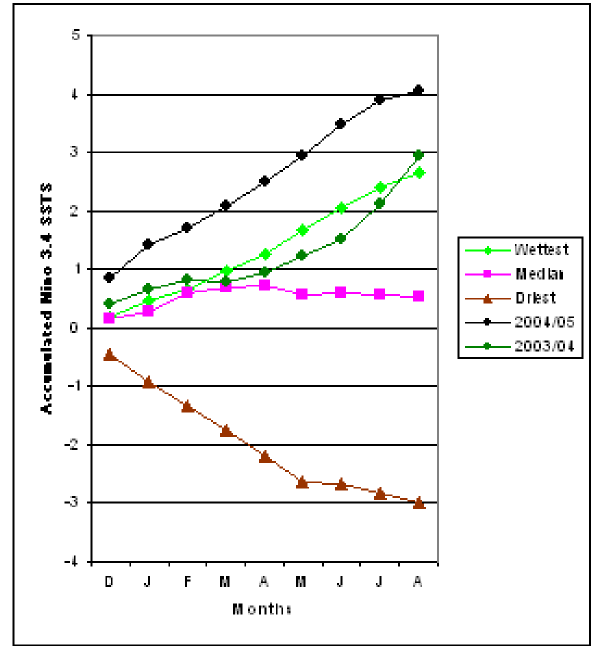


Fig. 6. Accumulated Nino 3.4 sea surface temperatures before and during June and July of the fifth and sixth May-Julys

Working Hypothesis re: causes of fifth and sixth wettest May-Julys during 1990-2010.
2005: Low sunspot activity, El Nino, westerly QBO Sept.-Dec., below normal Apr. NAS.
2004: Low sunspot activity, El Nino, below normal Apr. NAS

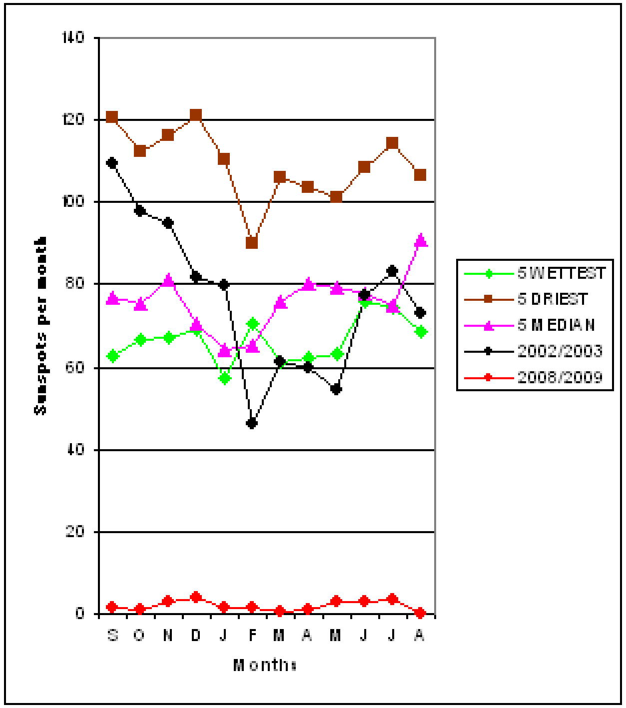


Fig. 7. Sunspots per month for two driest May-Julys

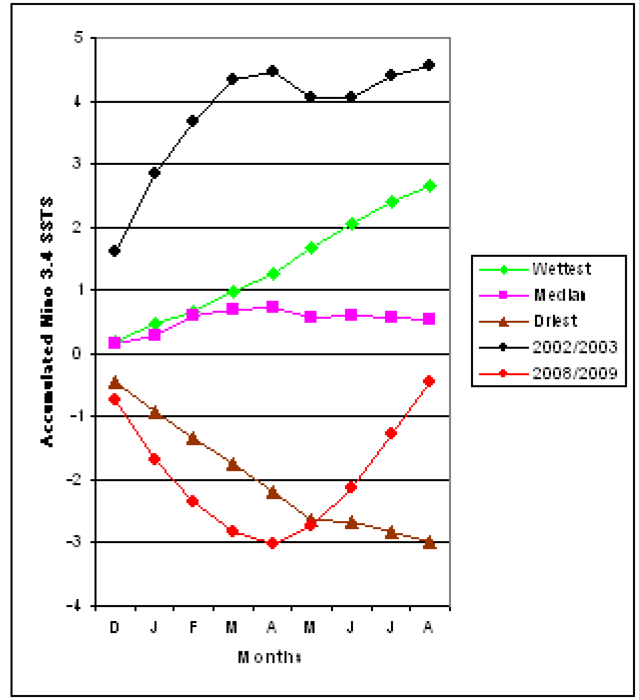


Fig. 8. Accumulated Nino 3.4 sea surface temperatures before and during June-July of the two driest May-Julys

Working Hypothesis re: causes for two driest May-Julys for the period 1990-2010

2003: Above average sunspot activity Sep-Aug, easterly QBO Dec-Jan

2009: La Nina conditions Dec-Mar (extremely late harvest, near record yields)

Table 1. Correlation coefficients of sunspots per month vs. PDSI values

Station	May	June	July	May-July	Data period	N
Brandon	-0.077	-0.119	-0.091	-0.104	1895-2001	107
Calgary	-0.094	-0.095	-0.098	-0.103	1895-2001	107
Coronation	-0.207	-0.183	-0.141	-0.183	1945-2001	57
Dauphin	0.030	0.040	0.073	0.051	1911-2001	91
Edson	-0.019	0.024	0.027	0.012	1920-2001	82
Edmonton	-0.132	-0.249*	-0.126	-0.189	1916-2001	86
Estevan	-0.278*	-0.299*	-0.259*	-0.289*	1944-2001	58
Medicine Hat	-0.192*	-0.186	-0.190	-0.195*	1896-2001	106
Prince Albert	-0.188	-0.207*	-0.252*	-0.230*	1895-2001	107
Regina	-0.180	-0.247**	-0.269***	-0.245**	1898-2001	104
Saskatoon	-0.141	-0.159	-0.179	-0.171	1902-2001	100
Swift Current	-0.217*	-0.179	-0.212*	-0.214*	1895-2001	107
Winnipeg	-0.123	-0.094	-0.121	-0.127	1895-2001	107

*Significant at the 5% level (two tailed)

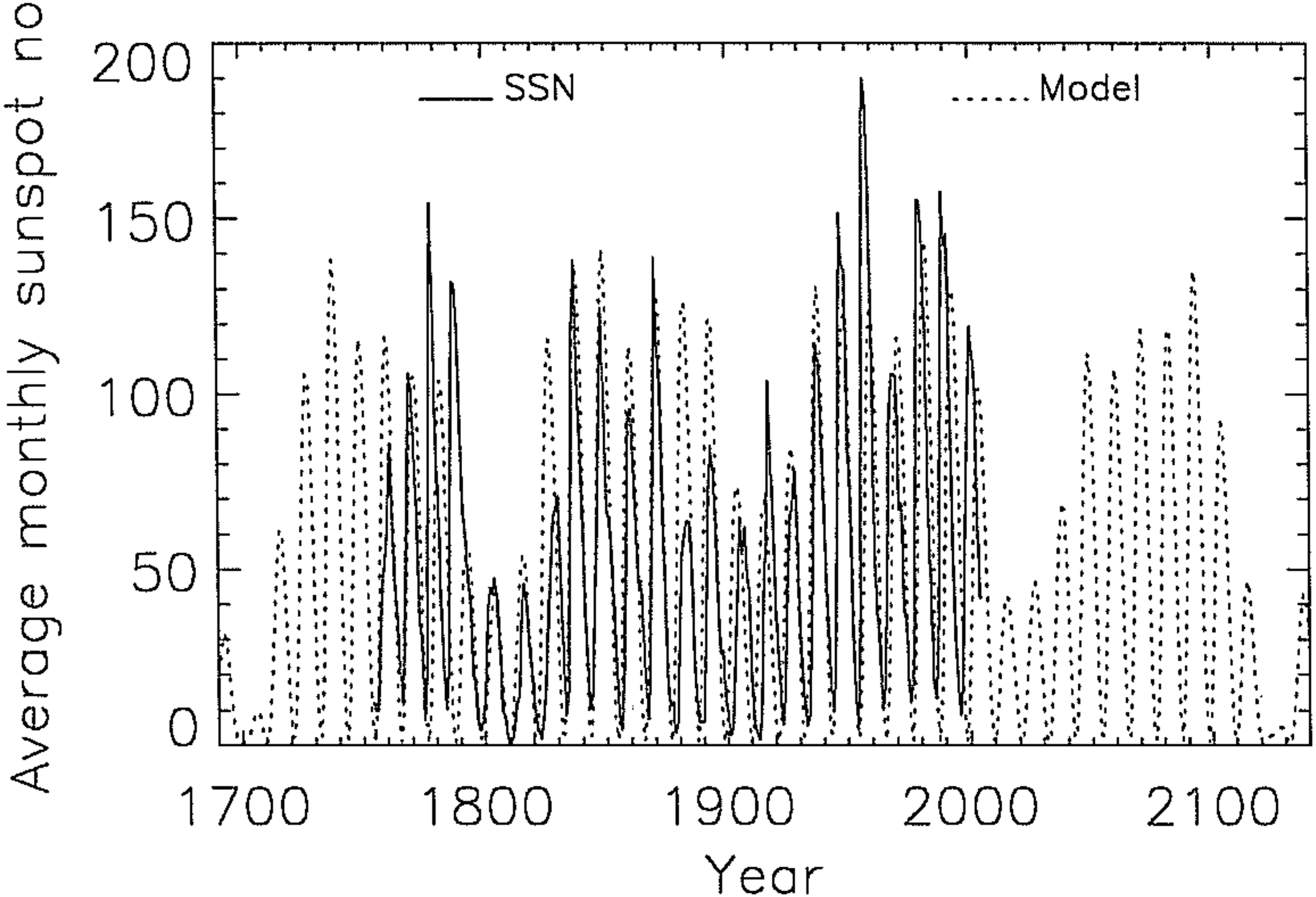
** Significant at the 1% level

*** Significant at the .1% level

Table 2. Drought and Flood Frequency during five Hale cycles since 1913

Polarity	Year in Cycle	Droughts (PDSI>-2.22)	Floods (PDSI > 1.36)
	1		1996
	2		1955
	3		
	4	1937	
	5	1938 1980	
Positive	6	1918 2001 1939	
	7	1919 1940	
	8	1920 1961 1941	
	9		
	10		1943
	11		
	12		1965
	13	1988	1966
	14	(2009)	
	15		1927 (2010)
Negative	16	1949	1991 1928
	17		1970
	18	1930	1951 1993
	19	1931	
	20		
	21		1974 1954
	22		1975

Based on June-Aug PDSI data 1913-2005 & (May-July precipitation 2005-2010)
Currently in year 16 of the Hale Magnetic or 22-year Double Sunspot cycle



SSN
Model
Average monthly sunspot no
200
150
100
50
0
1700
1800
1900
2000
2100
Year

CONCLUSIONS

* Since 1990 there have three times as many extremely wet May-Julys as extremely dry May-Julys.

* Results

Extremely wet May-Julys

	Sunspots	QBO	ENSO	NAS
2010	F		F	F
1991		F	F	F
1999	F			F
1993	F		F	F
2005	F	F	F	F
2004	F		F	F

Extremely dry May-Julys

	Sunspots	QBO	ENSO	NAS
2009			F	
2003	F	F		

*Significant correlations have been found between sunspot and PDSI data over the prairie region supporting the findings of Garnett et al 2006.

*Observational evidence suggests we are now in second half of the Hale Cycle when there has been about three times as many extremely wet May-Julys as dry May-Julys for the period 1913-2010.

*Some solar models predict the Sun could be entering a period like the Dalton Minimum at the time of Manitoba's Selkirk Settlers. A sunspot peak of no more than 50 sunspots per month around 2013-2014 would serve to confirm this.