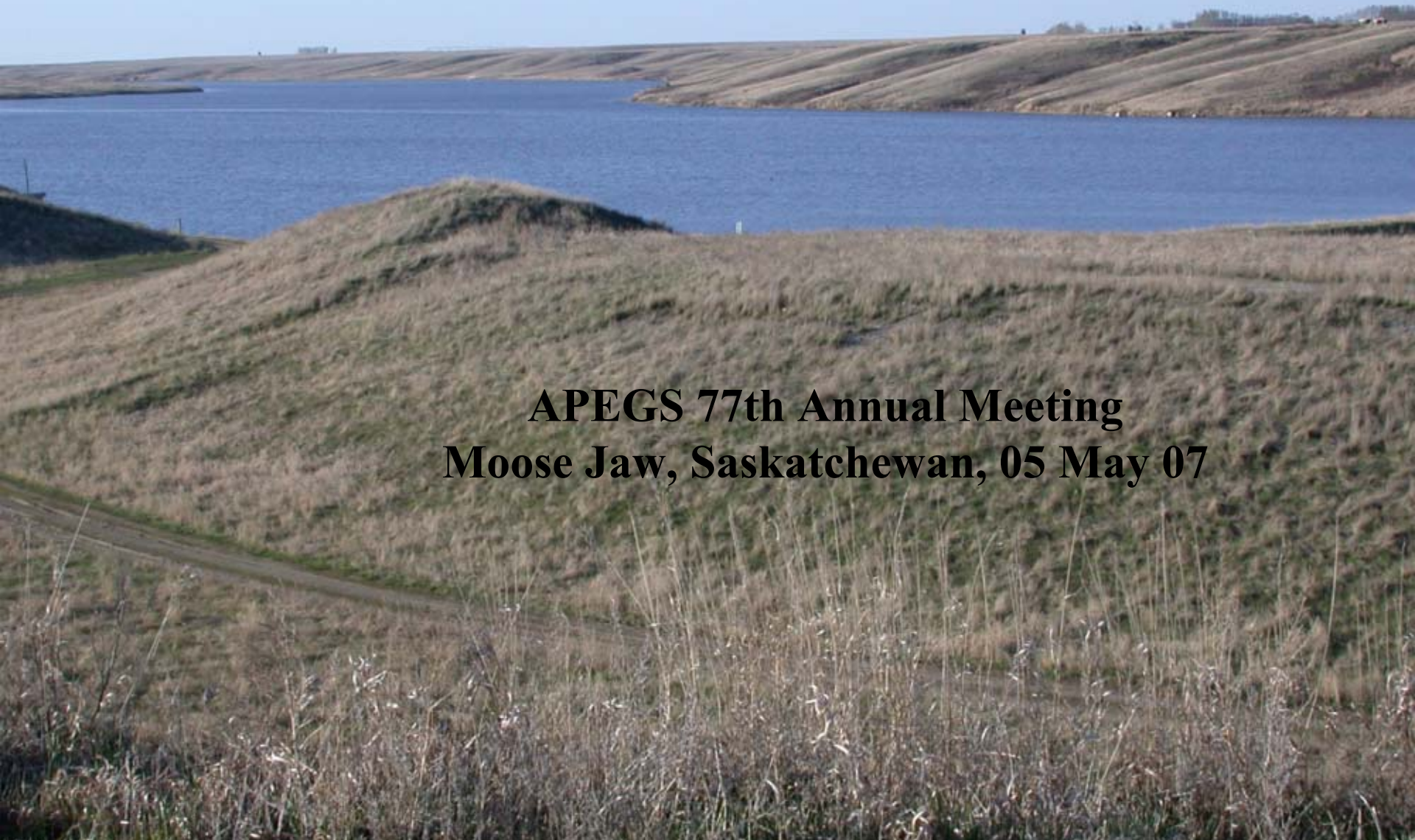
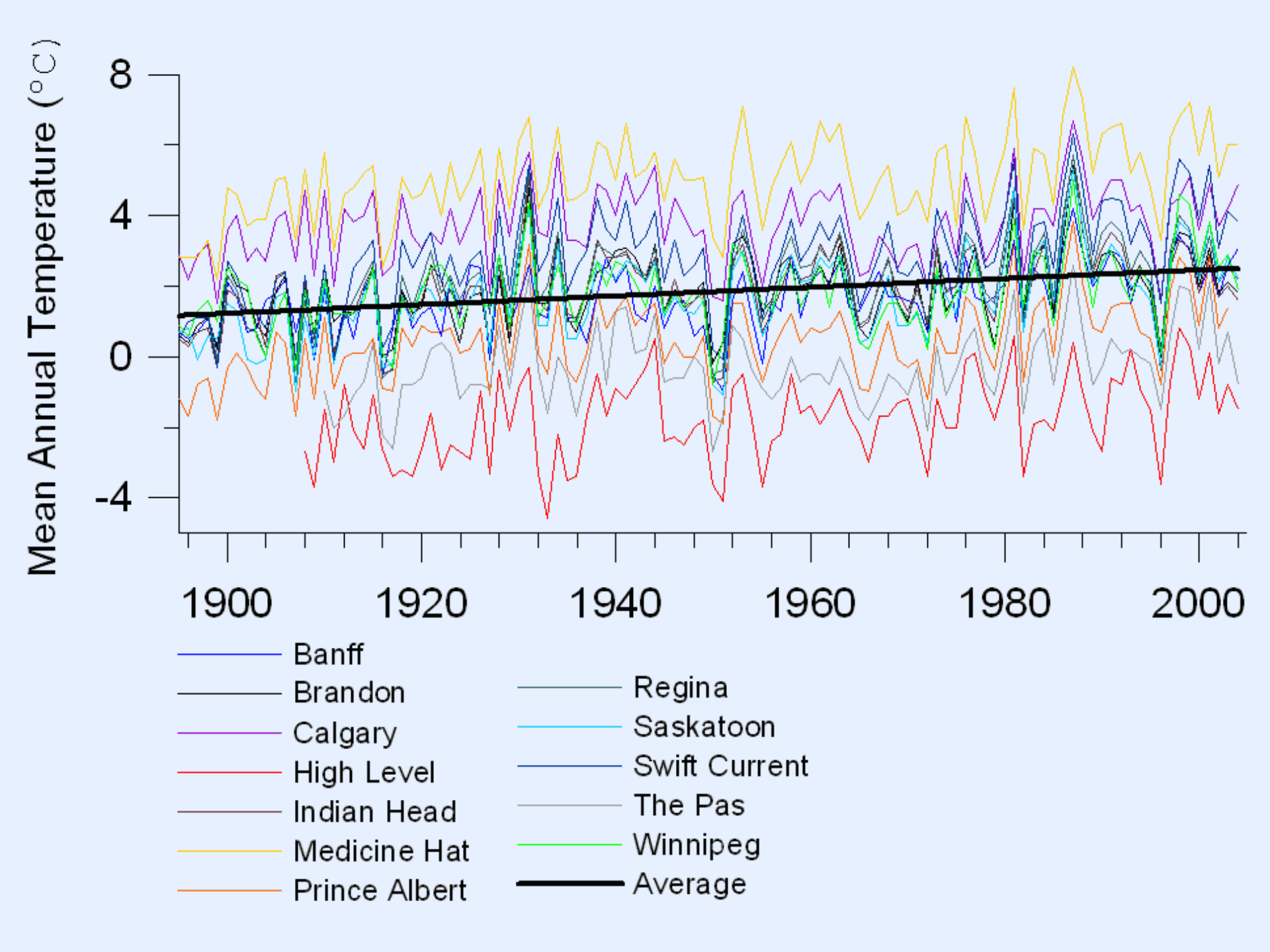
The Science of Climate Change: Potential and Realized Impact

Dave Sauchyn, Ph.D., P.Geo.
Prairie Adaptation Research Collaborative, University of Regina

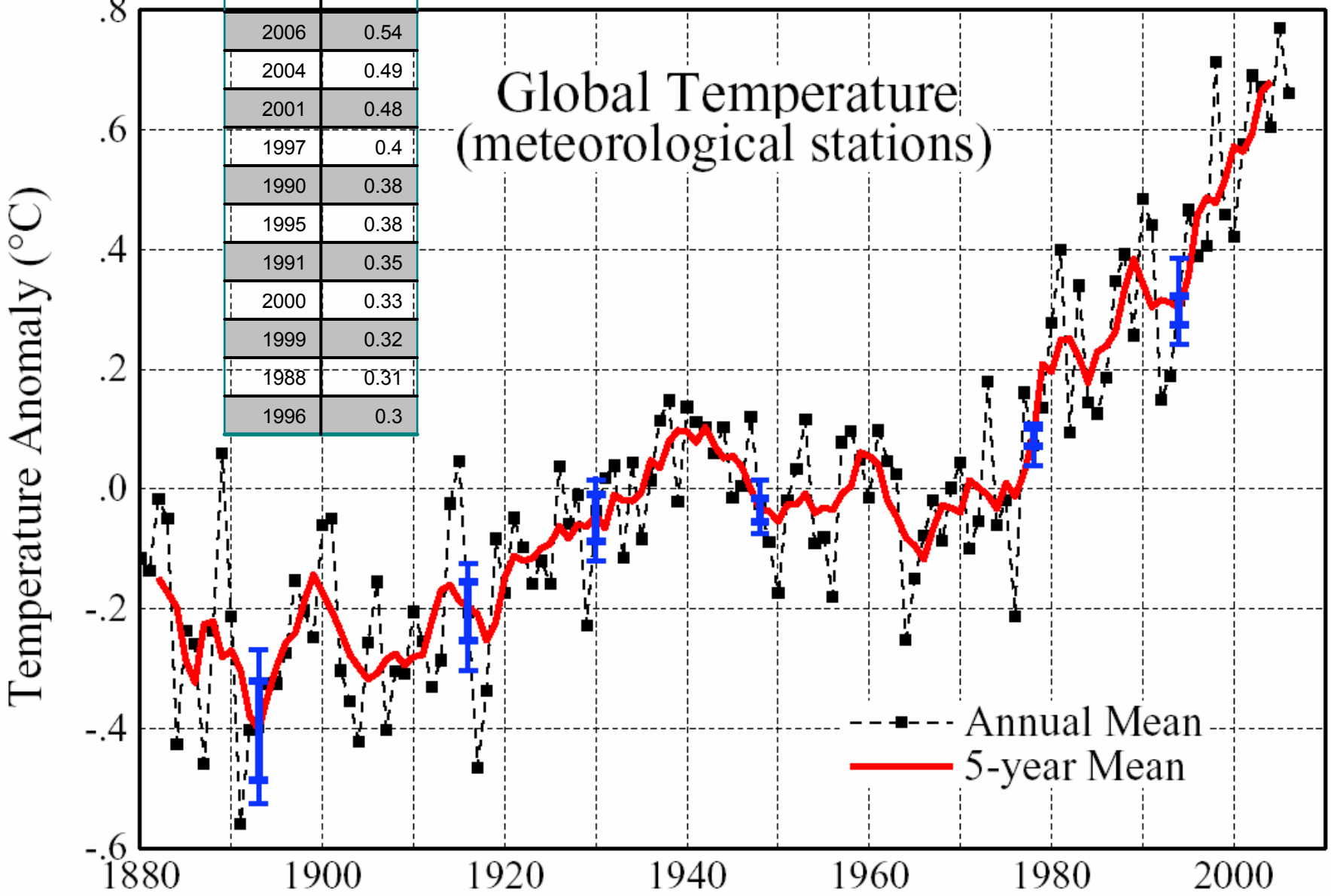


APEGS 77th Annual Meeting
Moose Jaw, Saskatchewan, 05 May 07

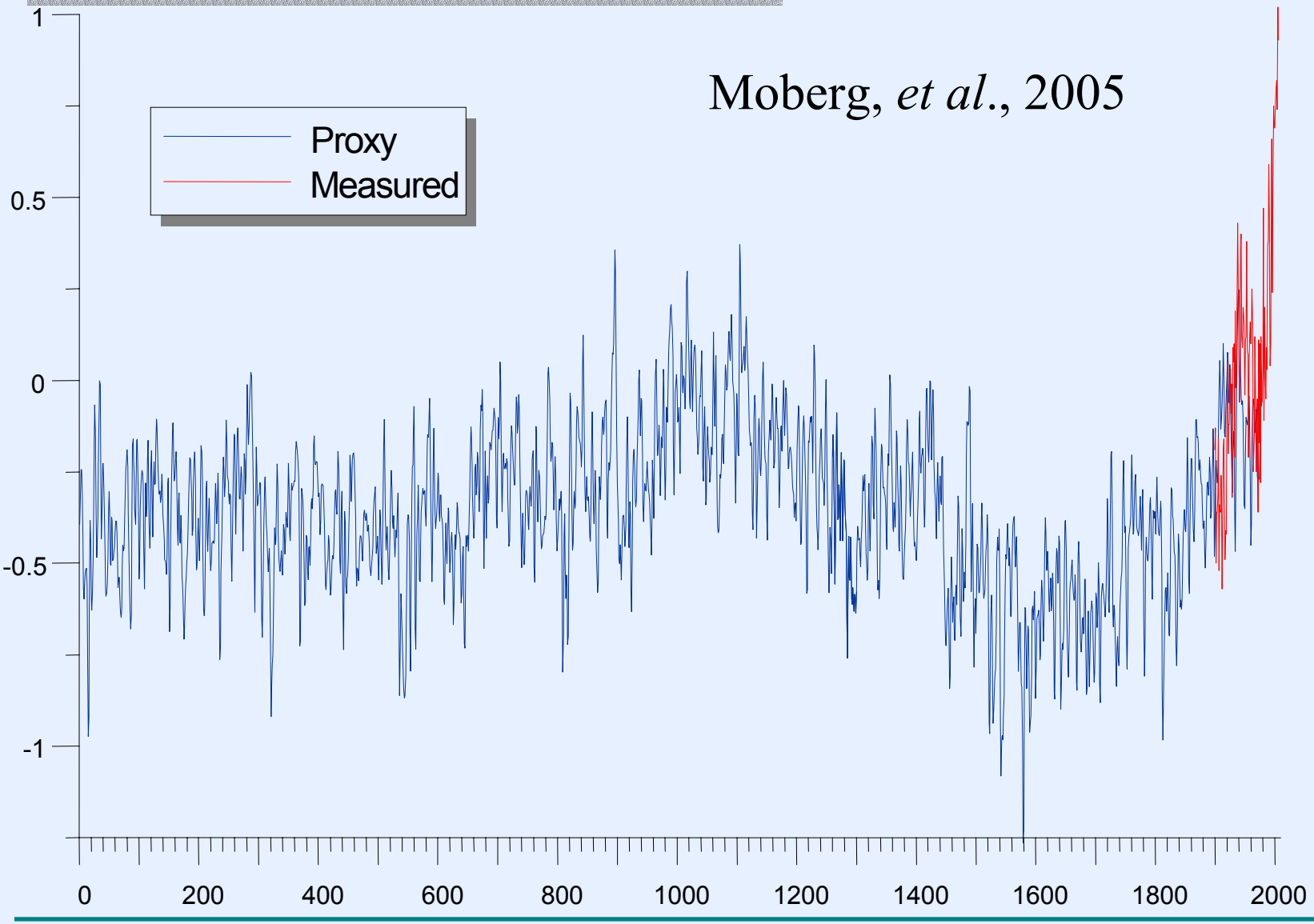

Mean Annual Temperature (°C)
8
4
0
-4
1900
1920
1940
1960
1980
2000
Banff
Brandon
Calgary
High Level
Indian Head
Medicine Hat
Prince Albert
Regina
Saskatoon
Swift Current
The Pas
Winnipeg
Average

2005	0.63
1998	0.57
2002	0.56
2003	0.55
2006	0.54
2004	0.49
2001	0.48
1997	0.4
1990	0.38
1995	0.38
1991	0.35
2000	0.33
1999	0.32
1988	0.31
1996	0.3

http://data.giss.nasa.gov/gistemp/



Northern Hemisphere temperature, past 2000 years

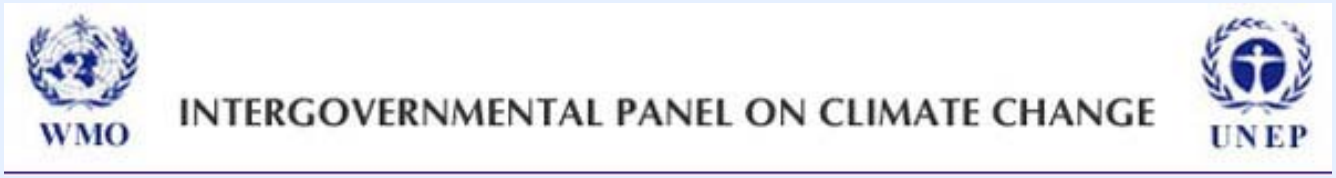


IPCC 4th Assessment Report

WMO INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE UNEP

- Warming of the climate system is unequivocal
- The warmth of the last half century is unusual in at least the previous 1300 years
- Most of the observed increase in globally averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations
- Warming would continue for centuries, even if greenhouse gas concentrations were to be stabilized

IPCC 4th Assessment Report



800+ contributing authors
450+ lead authors from 130+ countries
2500+ scientitic expert reviewers
6 years of work
4 volumes

Climate Change 2007: The Physical Science Basis - Summary for Policymakers, February 2, 2007

Canadian National Assessment – early fall, 2007

Canadian Climate Change Impacts and Adaptation Assessment
The Assessment Outline

The key sections of the Assessment are described below:

Synthesis Report

A concise overview of what climate change means for Canada. The report will highlight key findings, and discuss commonalities and differences among the regions. It will serve as both an executive summary and a value-added synthesis of the entire Assessment.

Section 1: Introduction/Overview

An introduction to the Assessment, emphasizing its goals and purposes, as well as the importance of understanding vulnerability.

Section 2: Climate and Climate Change in Canada

An overview of the importance of climate and climate change to Canada, with discussion of climatic, social and economic trends that affect exposure to climate. Will also outline future projections for Canada.

Section 3: Regional Chapters

The main content of the Assessment, these chapters will focus on current regional sensitivities and future vulnerabilities to climate and climate change. Case studies will be an important component of these chapters.

The regional chapters are:

- Atlantic Canada
- Quebec
- Ontario
- Prairies
- British Columbia
- The North

Section 4: Canada in an International Context

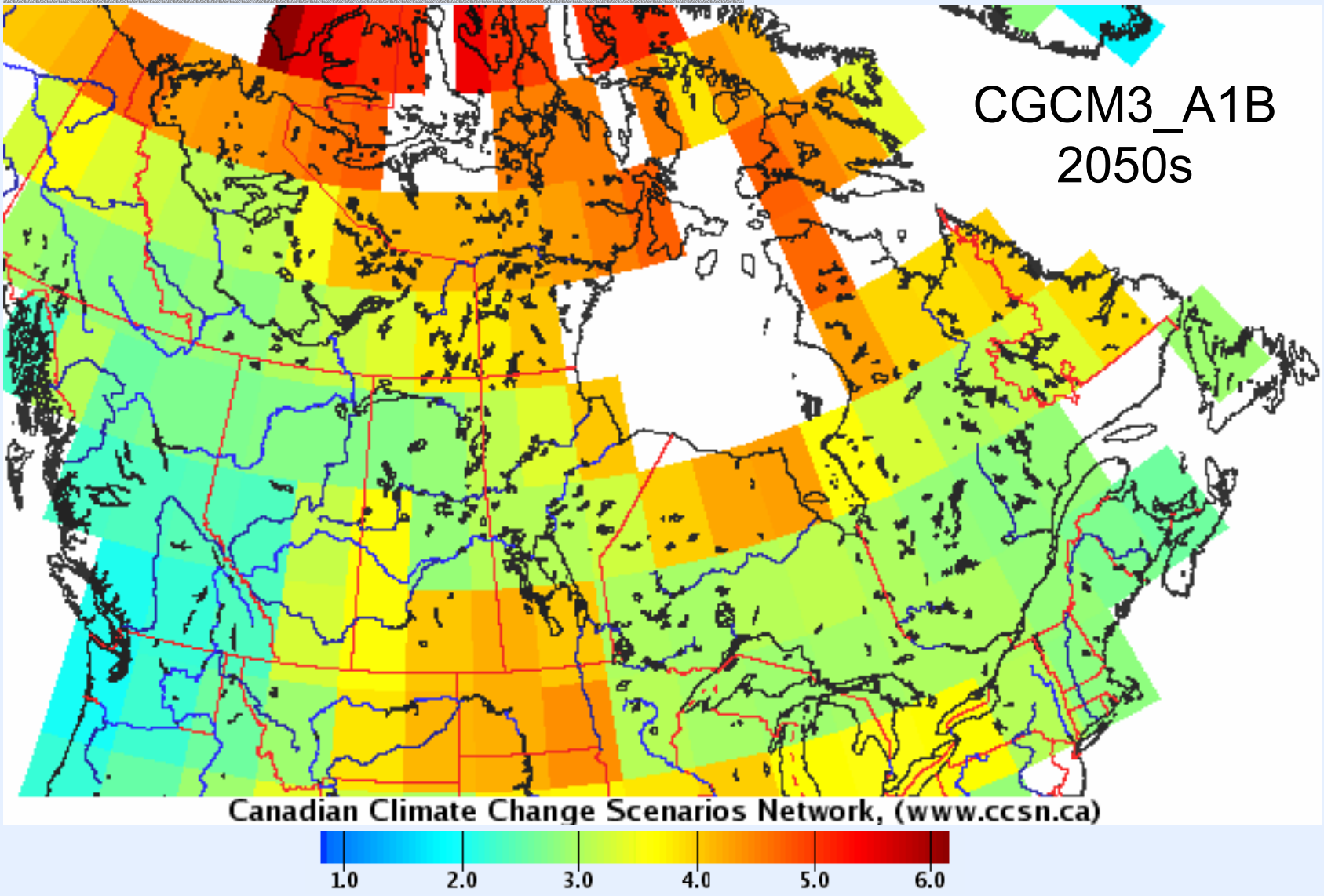
A broader perspective on climate change impacts and adaptation, which discusses climate change impacts and adaptation with respect to continental effects, oceans, global issues, and Canada's international obligations.

Section 5: Impacts and Adaptation Research- Capacity, Tools and Moving Forward

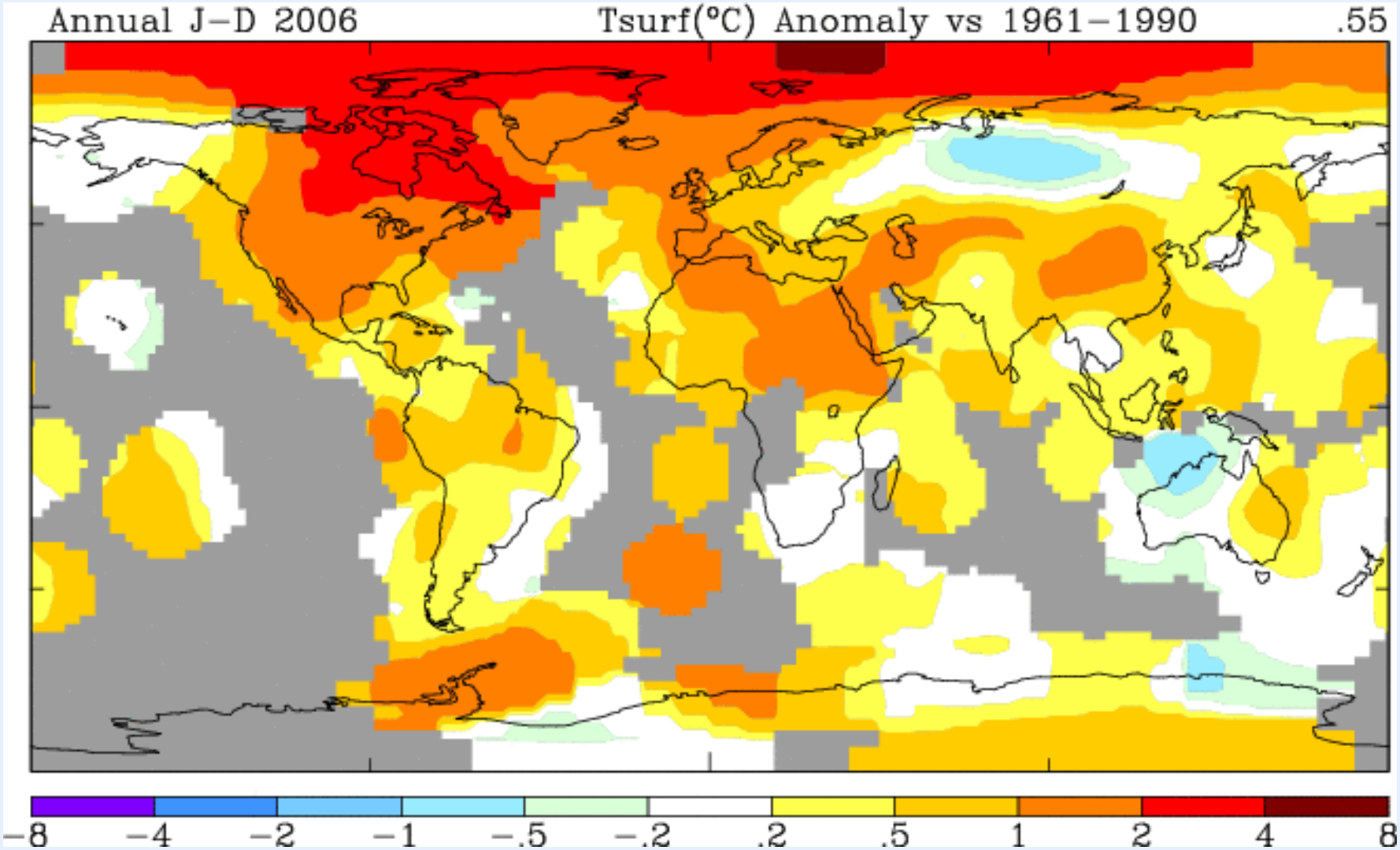
An examination of the present state of impacts and adaptation research in Canada, future directions and needs, and moving research to action.

http://www.adaptation.nrcan.gc.ca/assess_e.php

Mean annual temperature (° C) 2050s vs 1961-90)

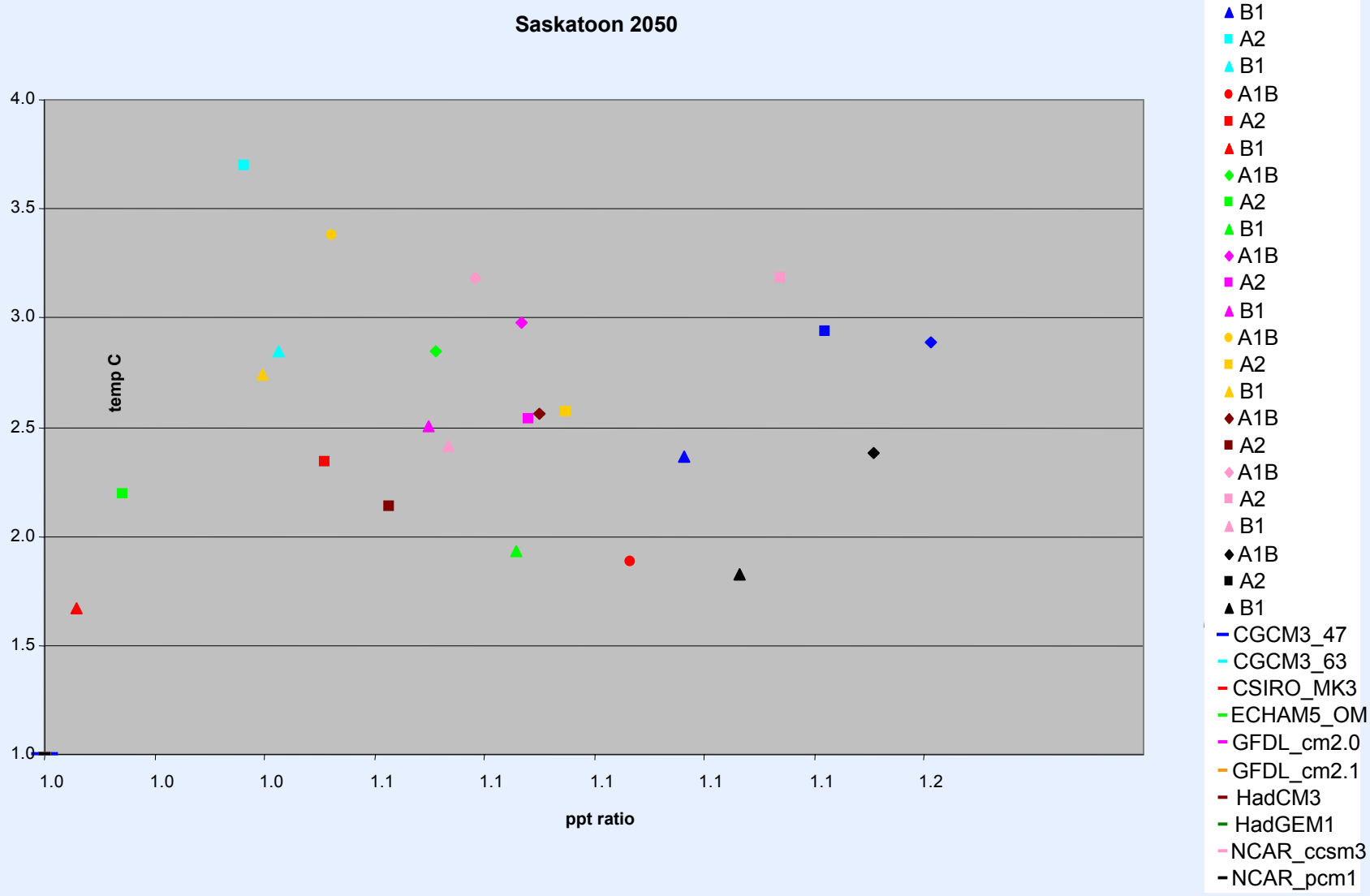


2006 Temperatures: Departures from Normal (1961-90)

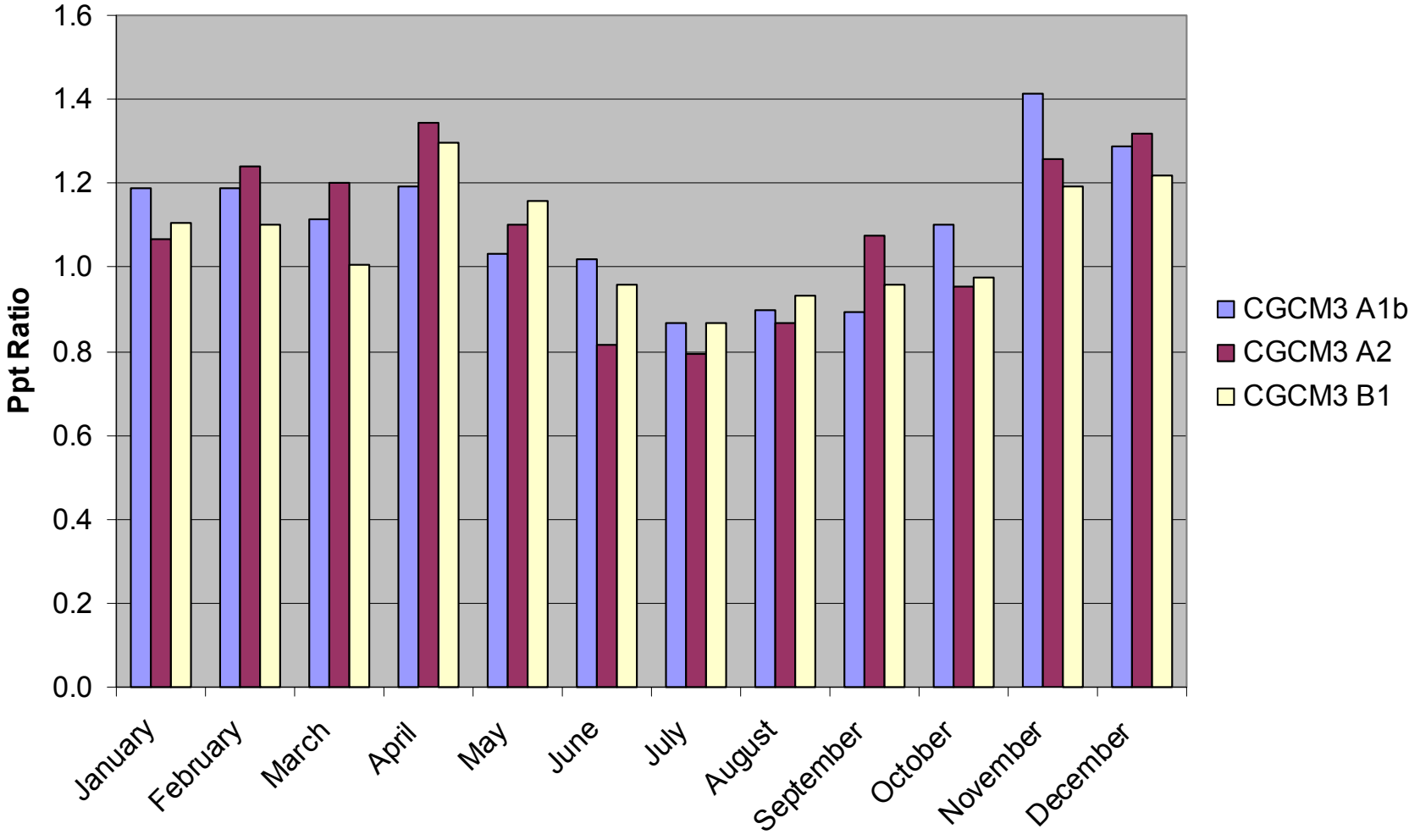


http://data.giss.nasa.gov/gistemp/

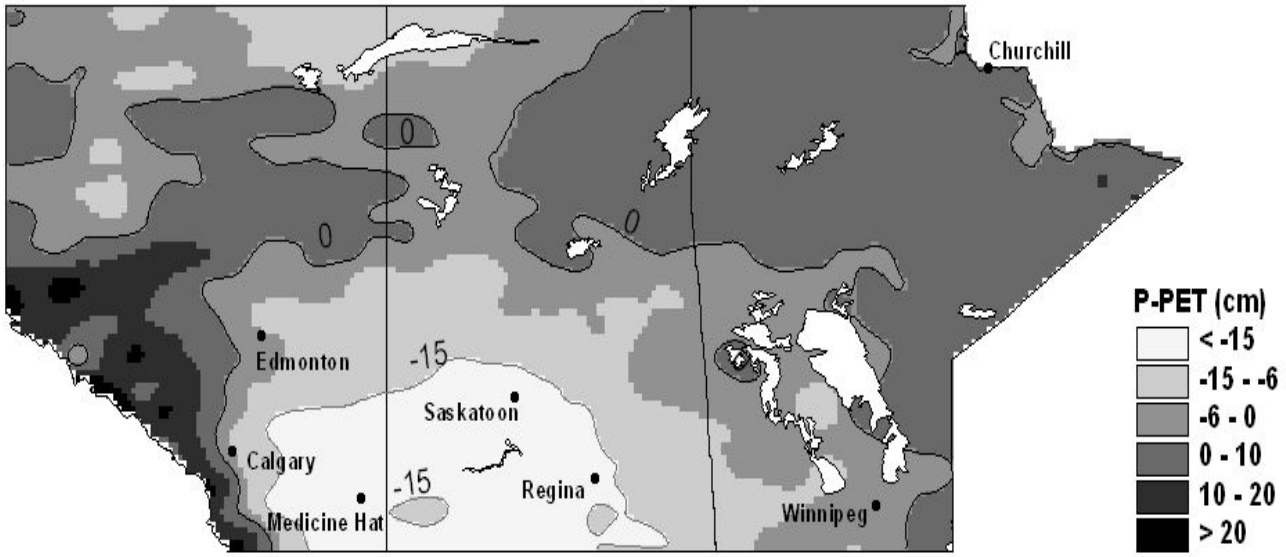
Temperature and Precipitation, Saskatoon, 2040-69 versus 1961-90



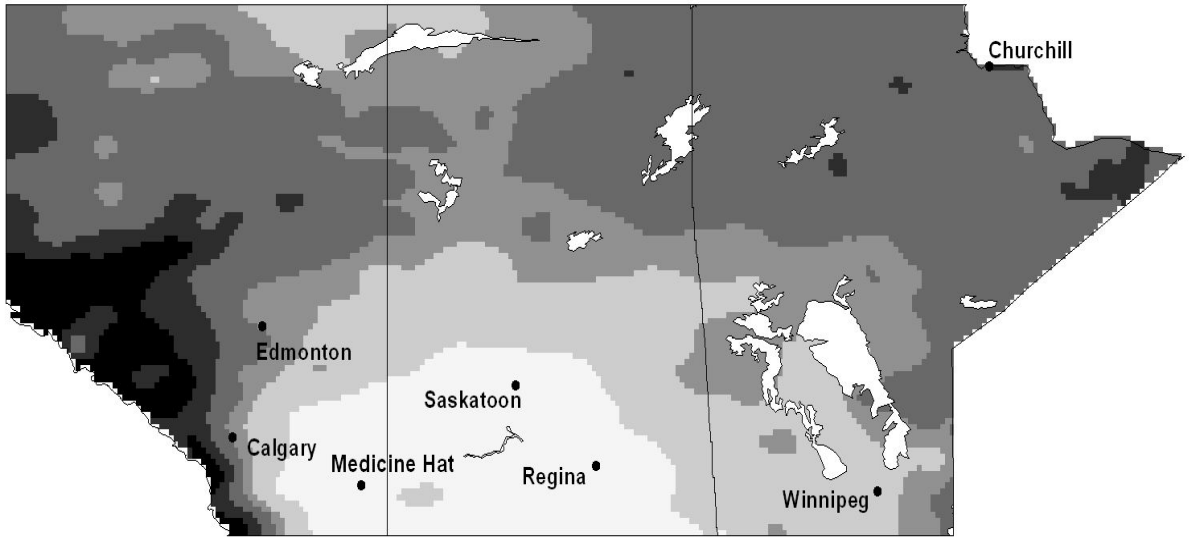
Precipitation: 2040-69 / 1961-90, Saskatoon



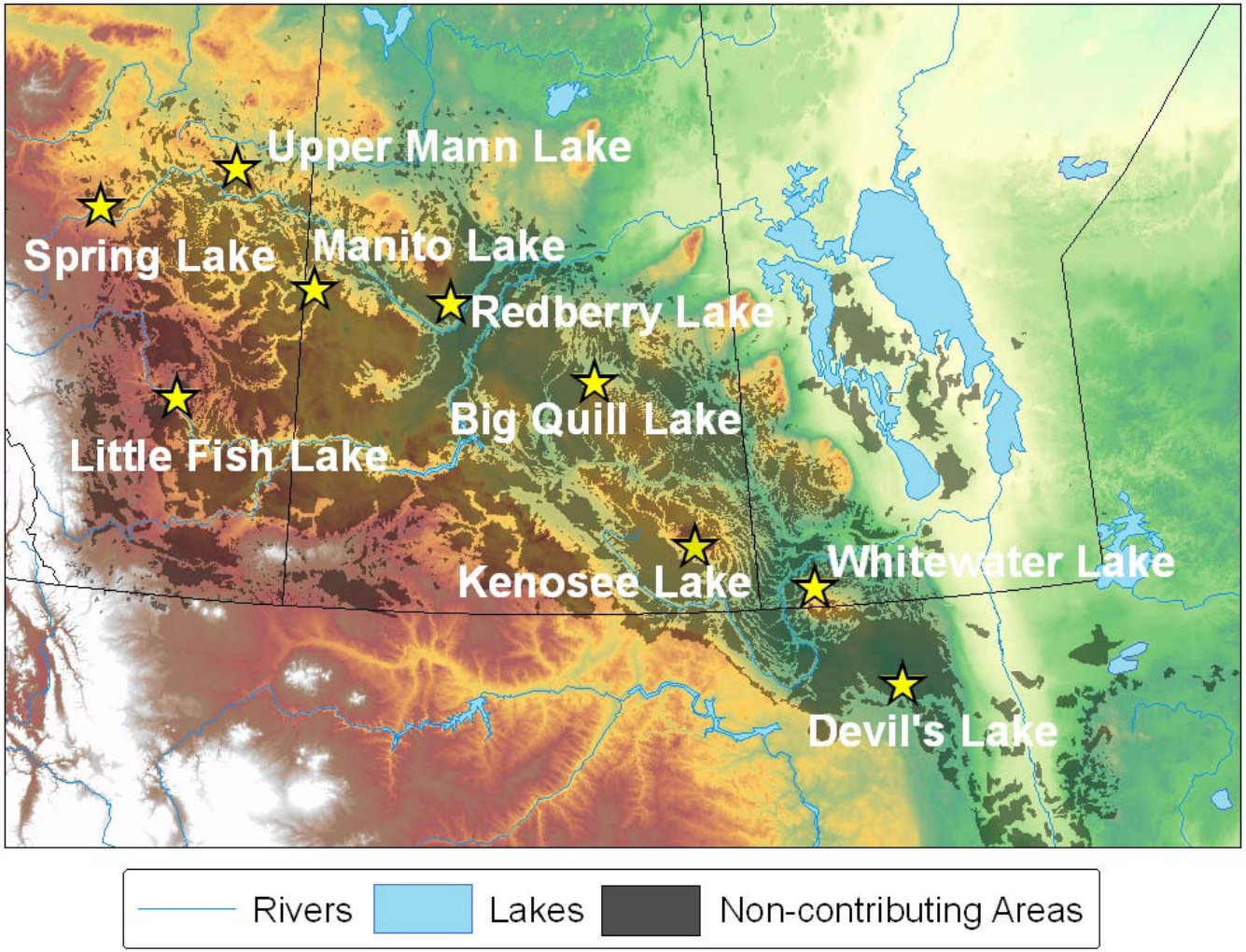
P-PET
1961-90



P-PET
2049-60

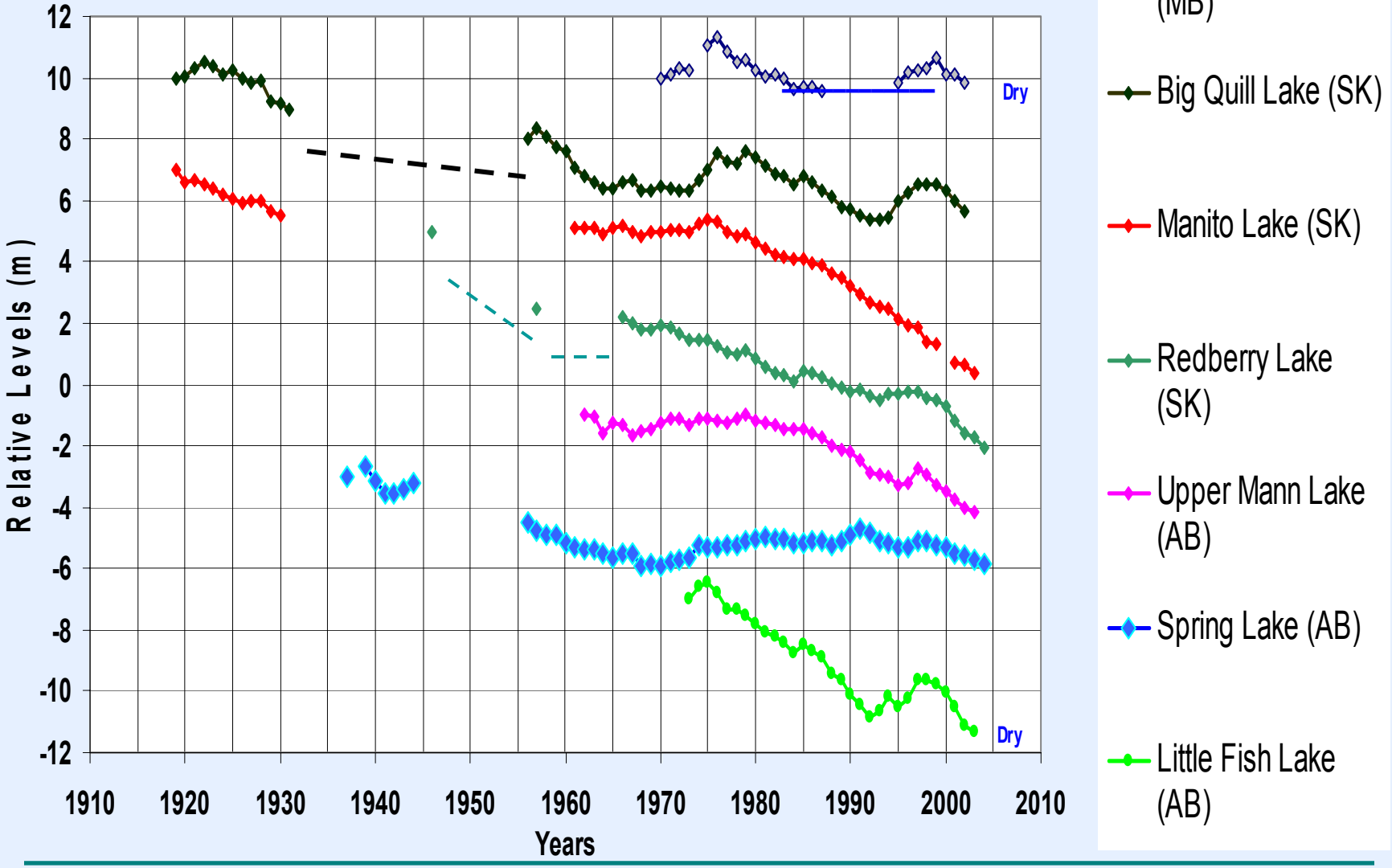


Closed-basin Prairie Lakes

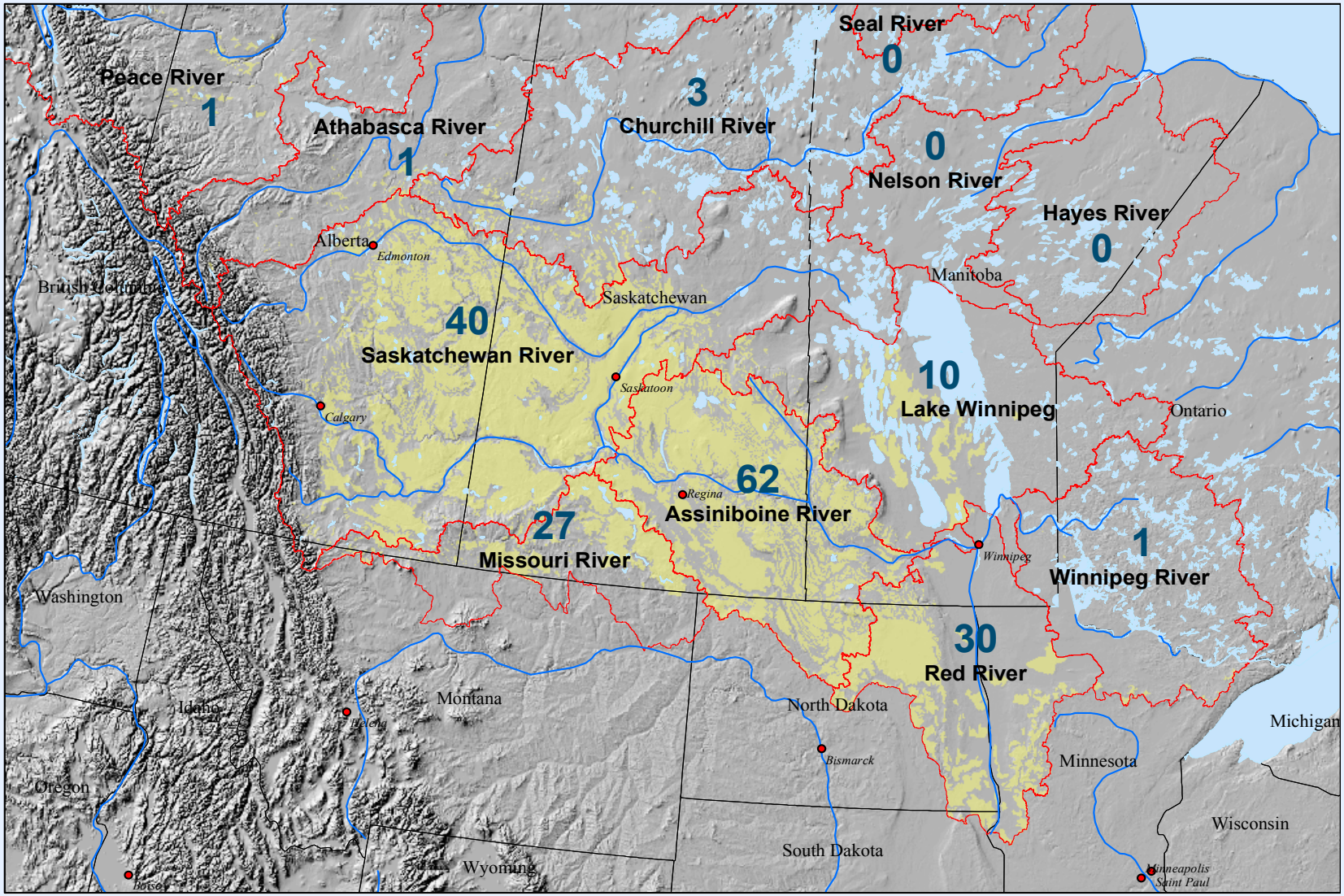


(van der Kamp *et al.*)

Closed-basin lake level changes, 1918-2004 (van der Kamp *et al.*)



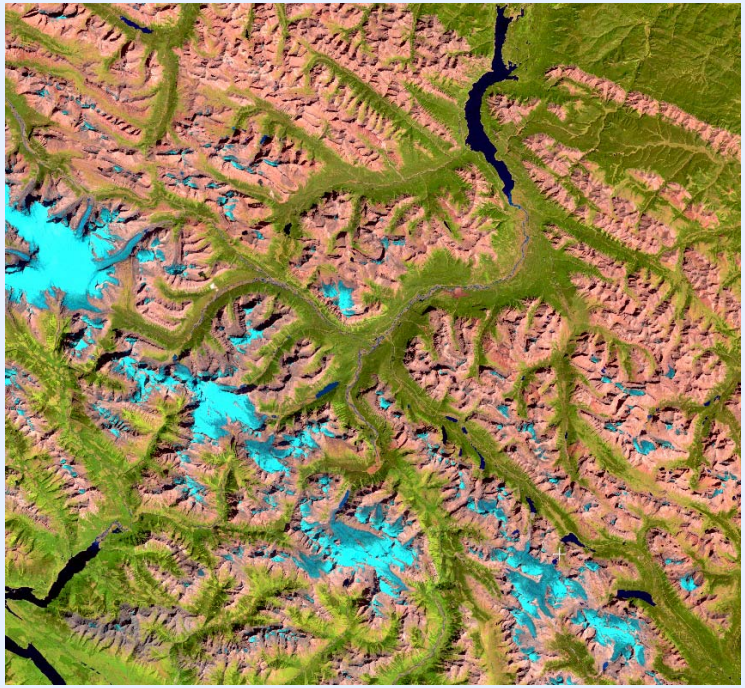
Prairie Drainage Basins (source: PFRA)



There are advantages and disadvantages to a shorter winter

Climate Change Impacts on Rocky Mountain glaciers

Demuth and Pietroniro, 2001



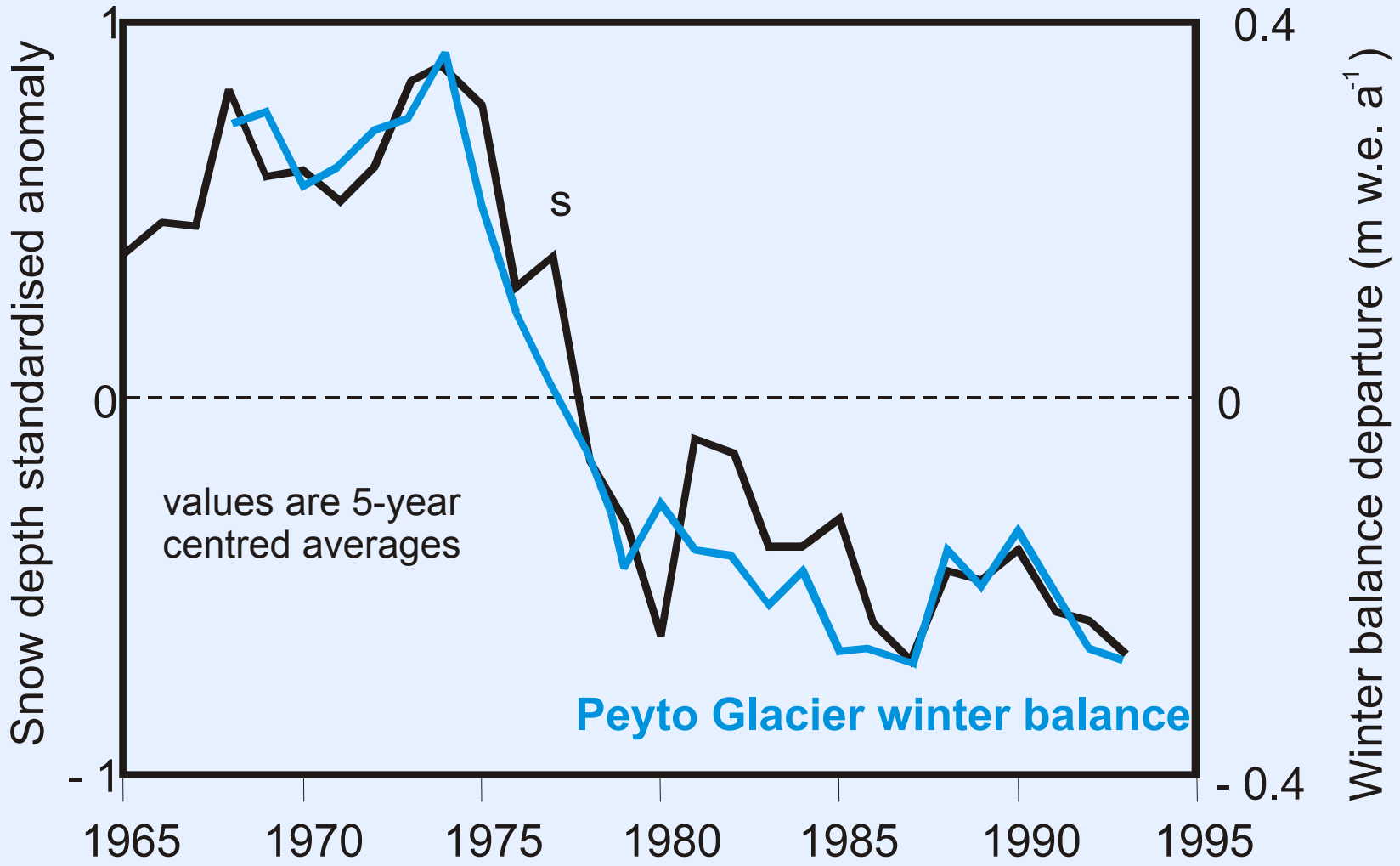
Glacier cover has decreased rapidly in recent years; it now approaches the least extent in the past 10,000 years

A phase of increased stream flow from global warming has past; basins have entered a potentially long-term trend of declining flows

Declining supplies of glacier runoff have serious implications for the adaptive capacity of downstream surface water systems and for trans-boundary water allocation

Eastern slopes/western prairie March snow depth

Demuth and Pietroniro, 2001

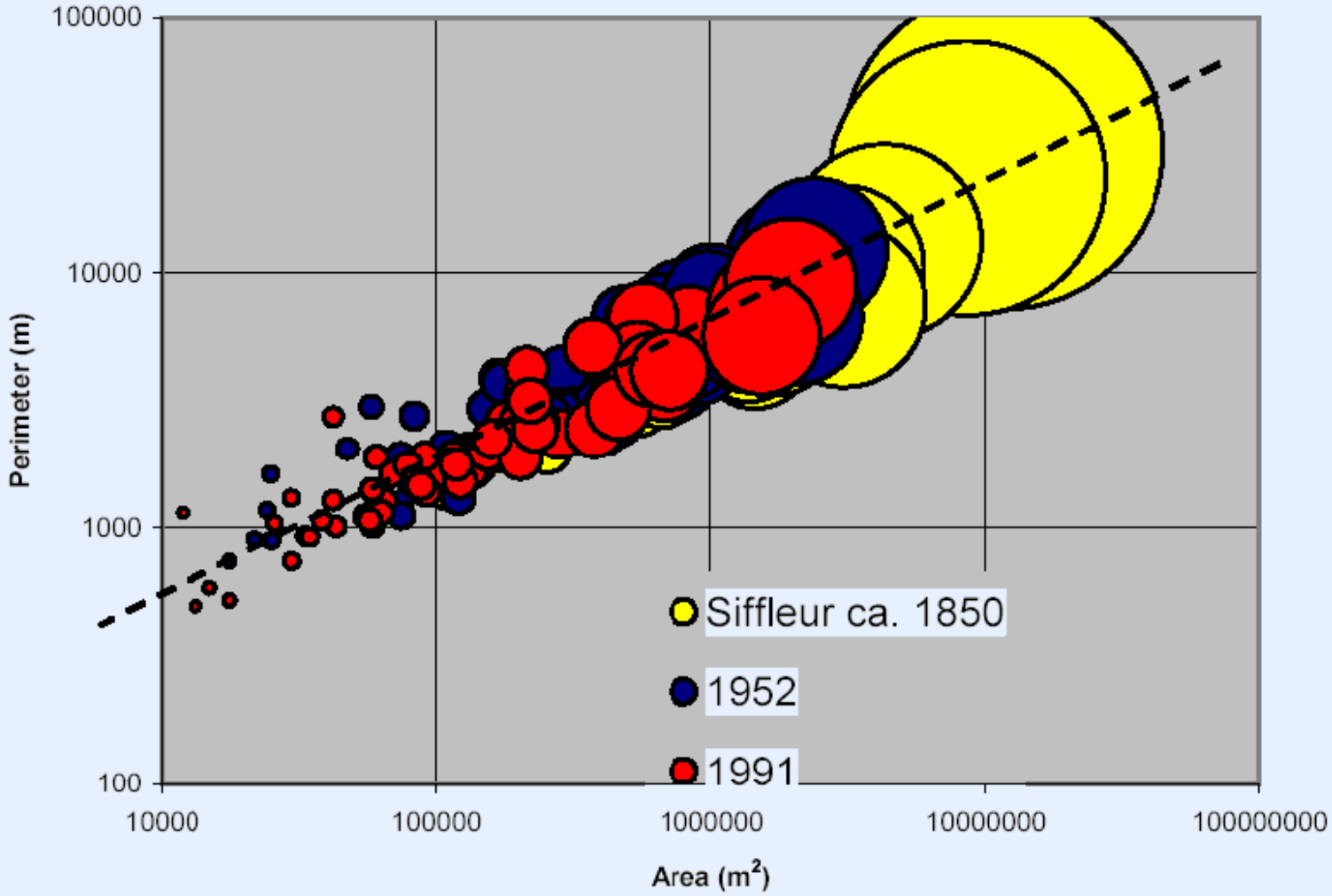


Peyto Glacier

2006

M.N. Demuth

Shrinking Glaciers (Demuth and Pietroniro, 2001)

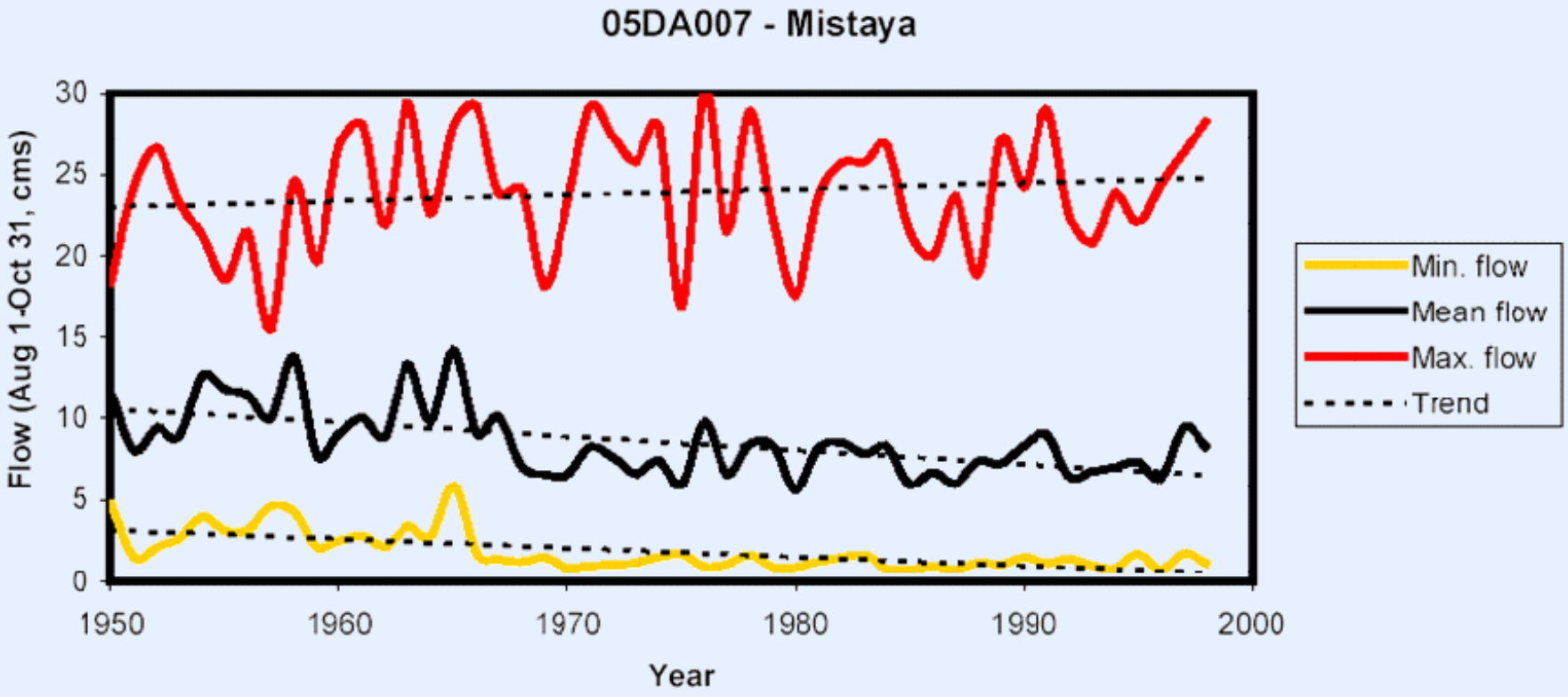


Estimated Glacier Melt Contribution

	TBF %	Annual %
	7.4	**1.8**

	TBF %	Annual %
	2.4	**0.6**

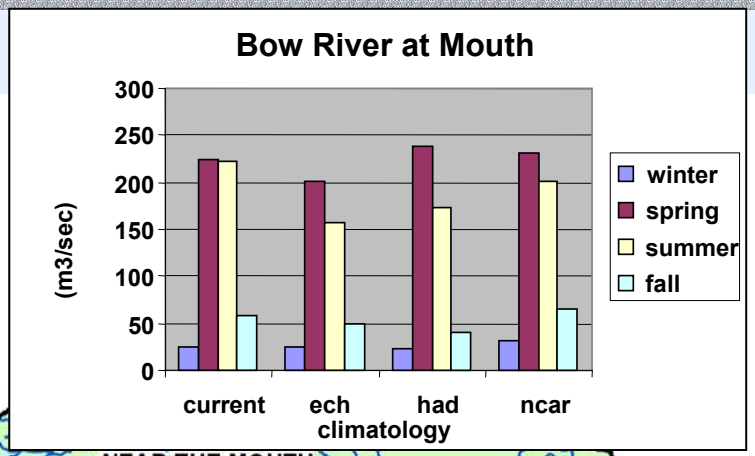
Declining Mean and Minimum Streamflow

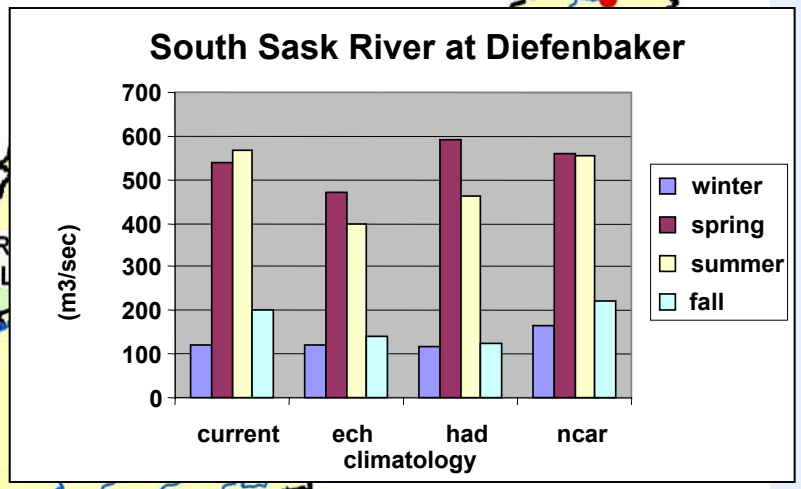


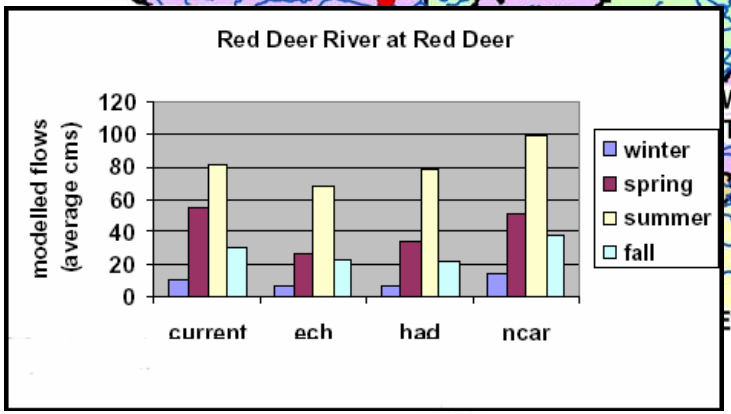
Demuth and Pietroniro, 2001

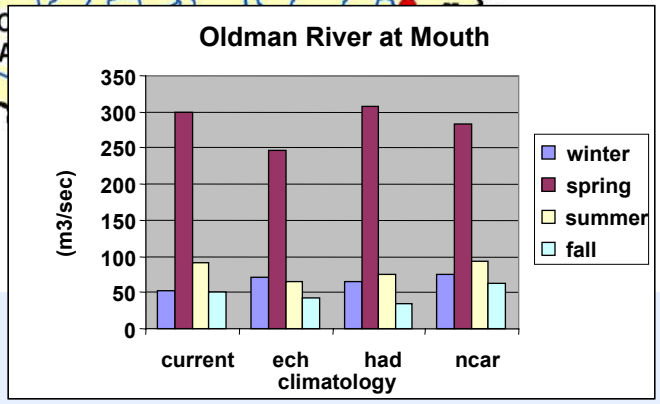
Seasonal flows, SSRB, 2039-2070 (Pietroniro *et al.*, 2006)

GCM	%Precip	+Temp	Description
echa21	-3.8	2.8	driest, warmest
echb21	-2.0	2.8	
hada21	6.4	2.3	moderately wet and warm
hadb21	0.2	2.1	
ncara21	11.5	1.7	wettest and least warm
ncarb21	9.1	1.5	

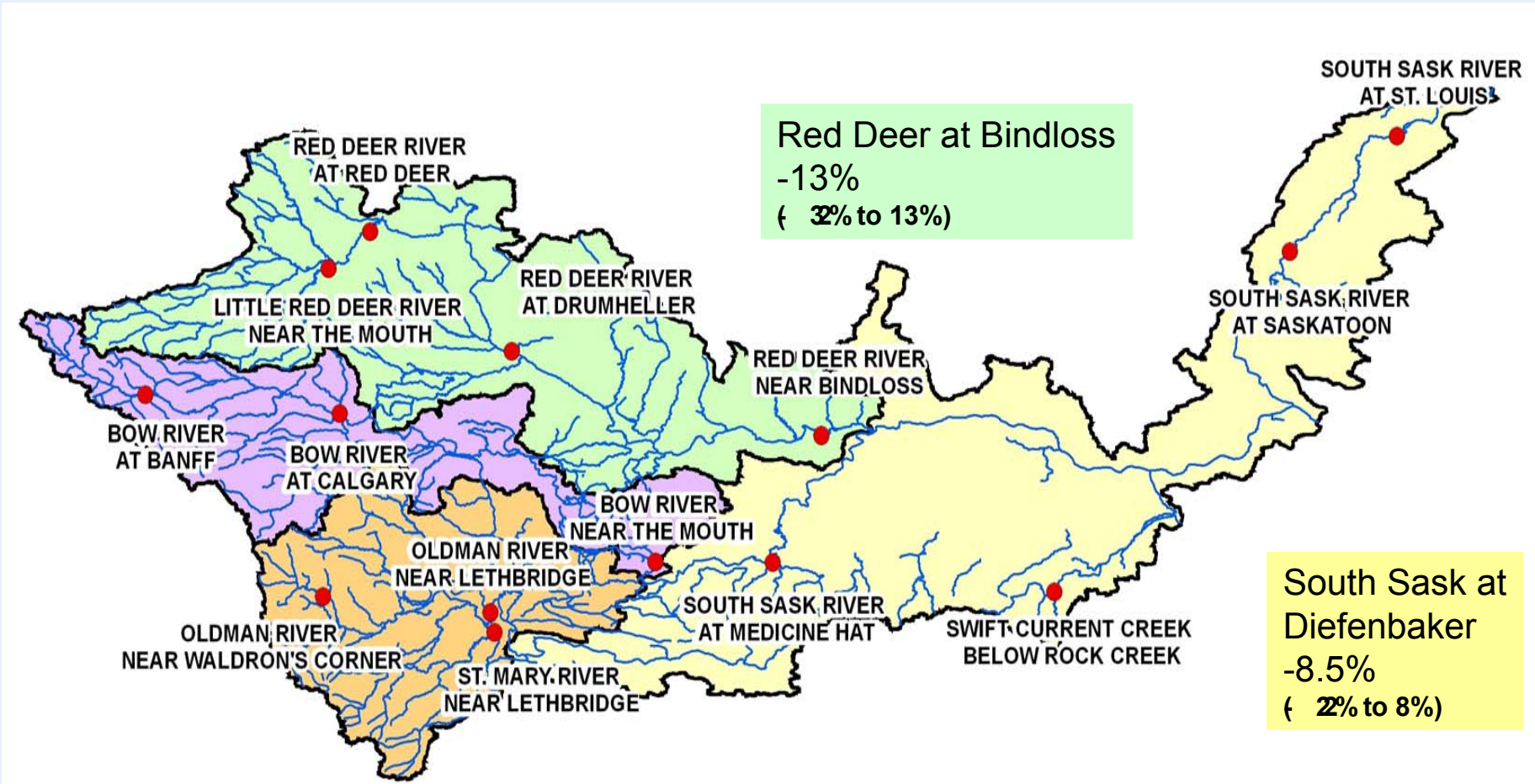








Annual flows, SSRB, 2039 – 2070 (Pietroniro *et al.*, 2006)

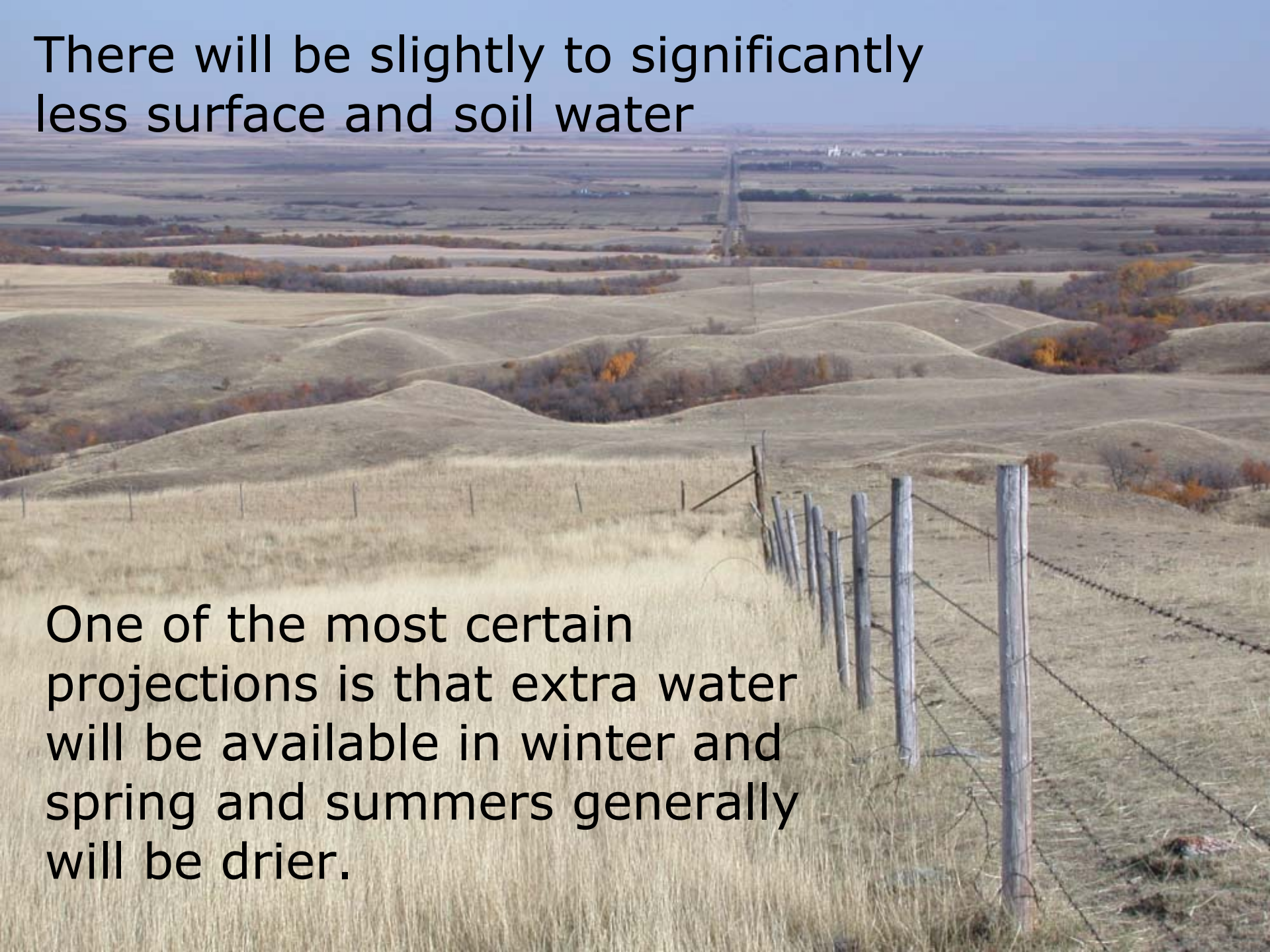


Red Deer at Bindloss
-13%
(-32% to 13%)

South Sask at Diefenbaker
-8.5%
(-22% to 8%)

Bow River at mouth
-10%
(-19% to 1%)

Oldman at mouth
- 4%
(-13% to 8%)

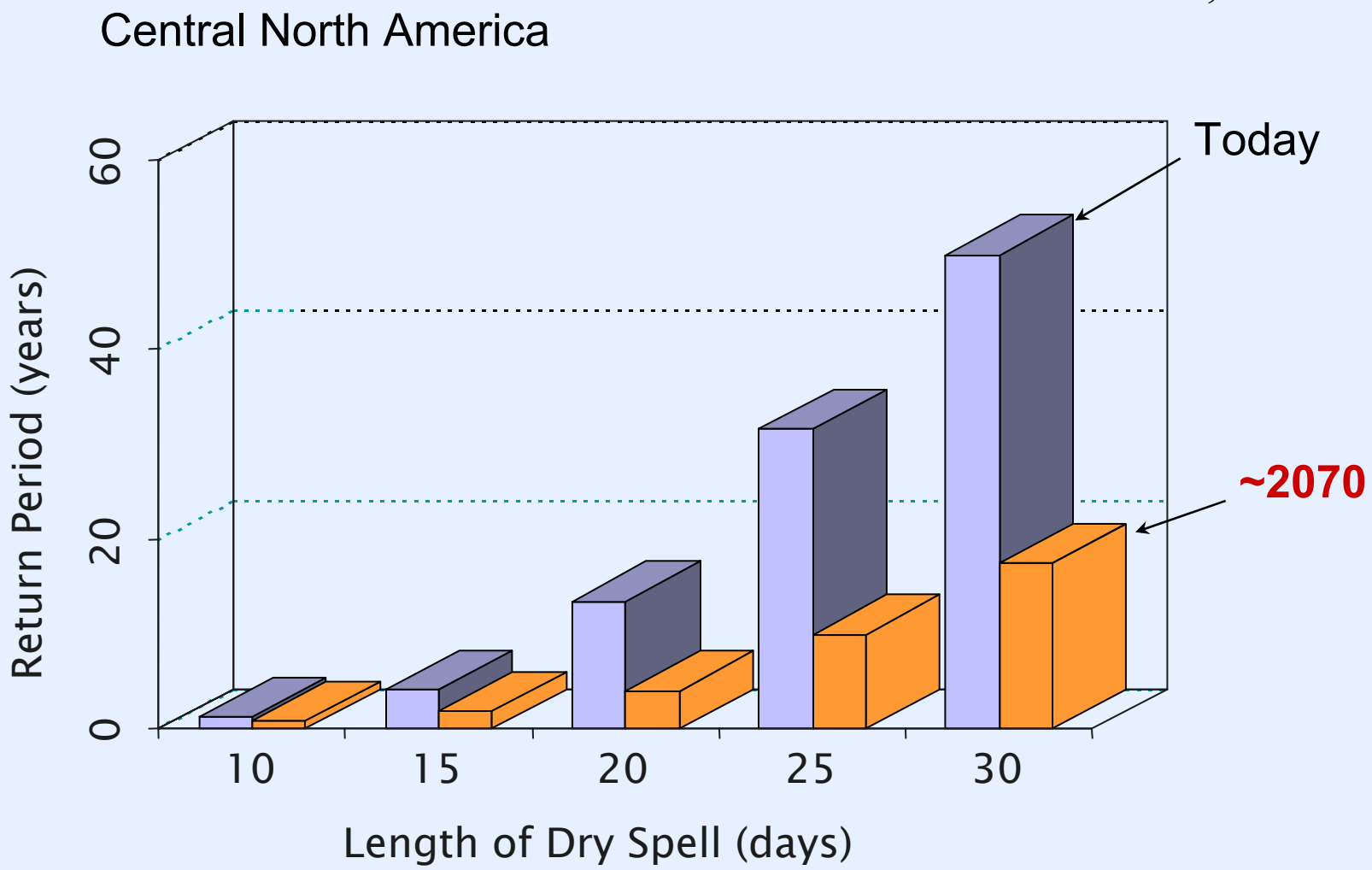

There will be slightly to significantly less surface and soil water
One of the most certain projections is that extra water will be available in winter and spring and summers generally will be drier.

There will be greater variation from season to season and year to year

Both drought and unusually wet years could occur with greater frequency and severity

Increasing Drought Frequency

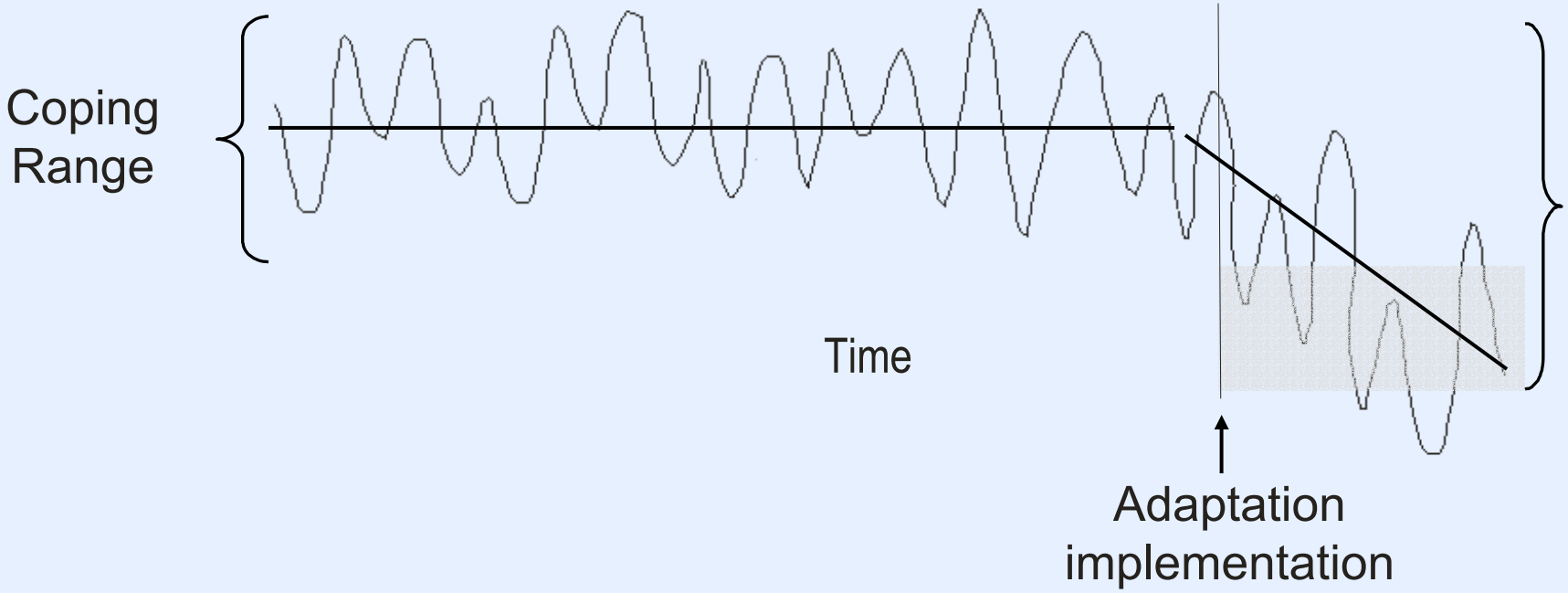
Kharin and Zwiers, 2000

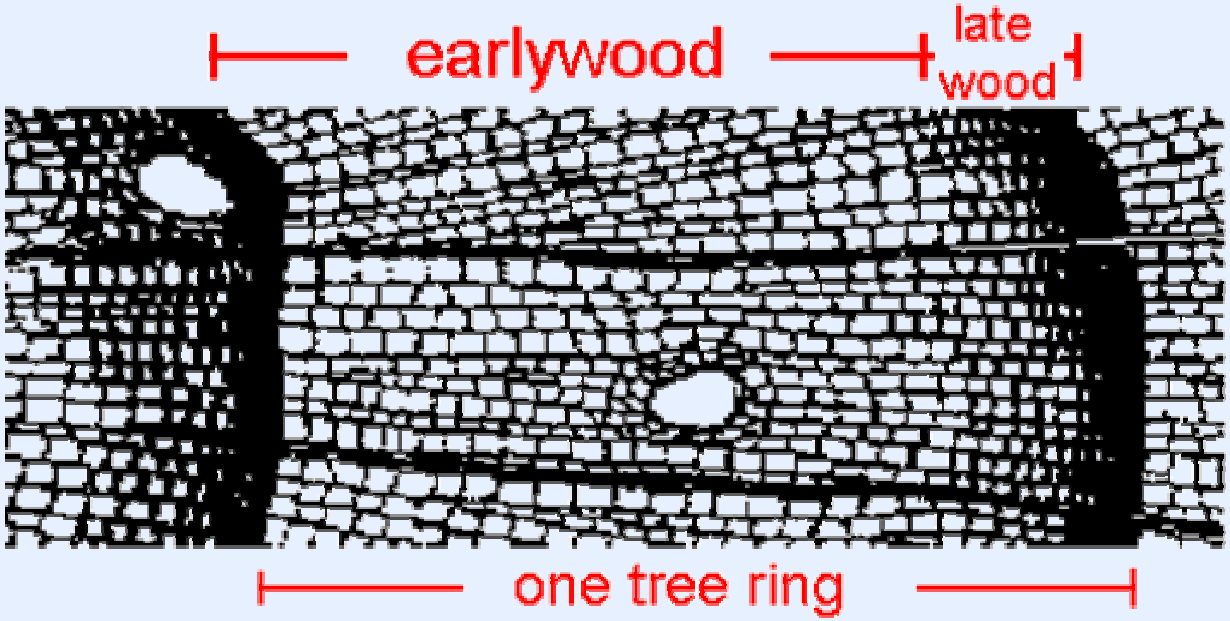


Trend (change) versus Variability

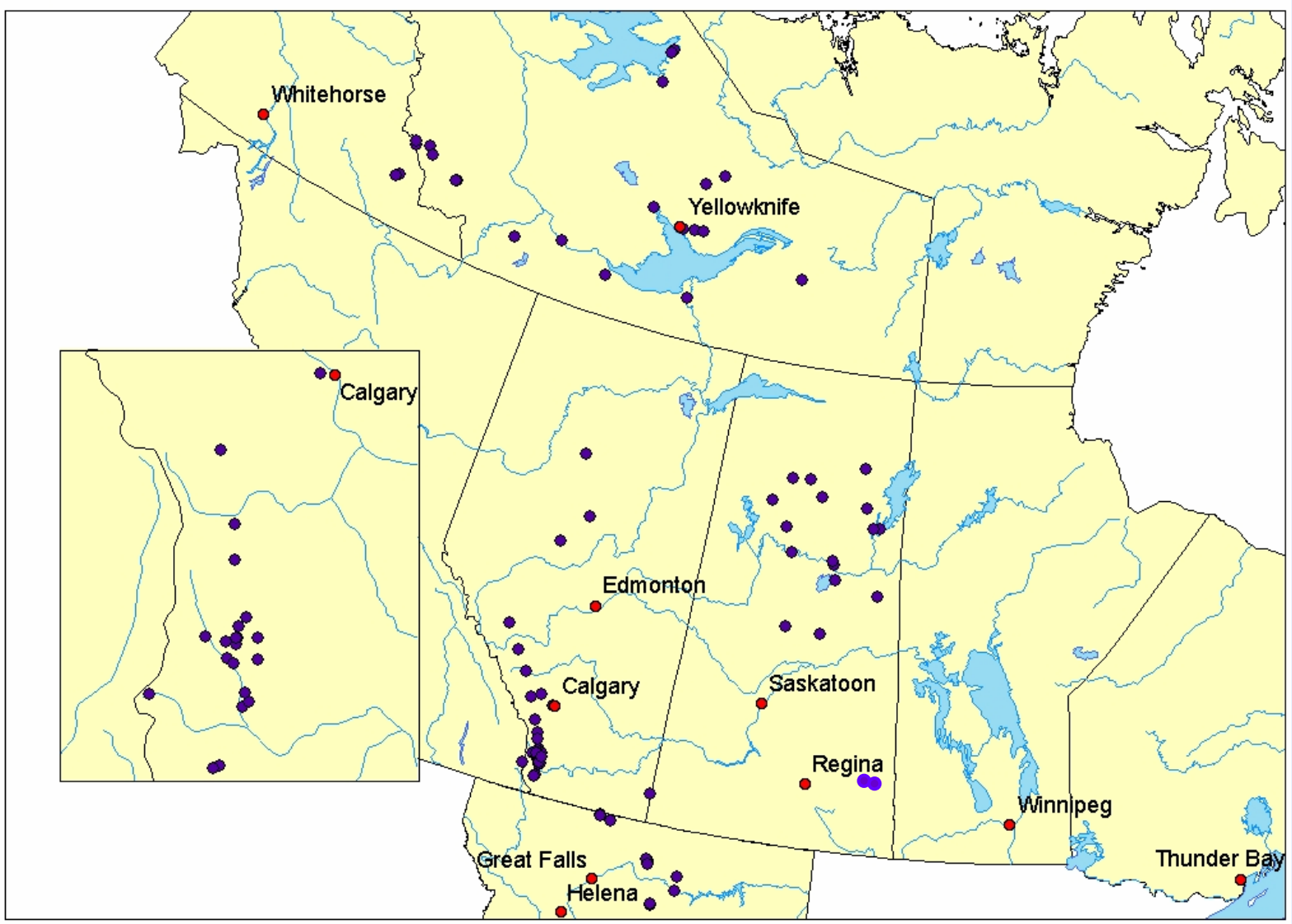
Climatic variability

Climatic change




earlywood
late wood
one tree ring

Tree-Ring Network



Why proxy hydroclimate data?

Most gauge records are too short to capture the decadal and longer-term variation in the regional climate and hydrology. Sustained departures from mean hydroclimate are observable only with proxy (surrogate) climatic and hydrometric data. Most drivers of climate variation have a periodicity that approaches or exceeds the length of instrumental records.

Proxy Streamflow Records for Water Planning In Western Canada
Dave Sauchyn, Jodi Axelson and Antoine Beriault
The Technical Bureau Supplement
Water News, June, 2006

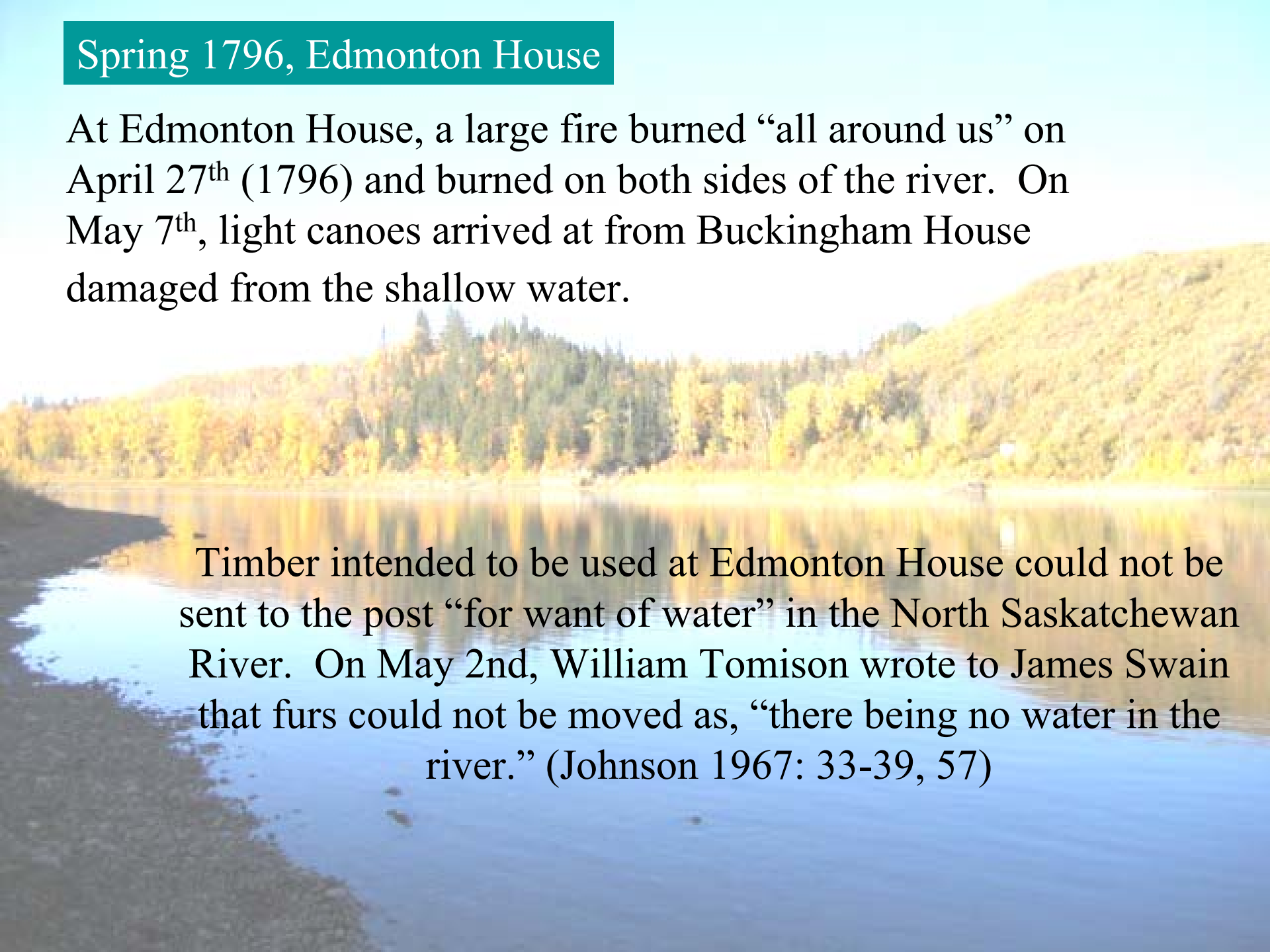
Why proxy hydroclimate data? (Sauchyn *et al*. 2006)

Can provide water resource planners and engineers with

- a context for reference hydrology to evaluate baseline conditions and water allocations
- worst-case scenarios - what is possible in terms of the severity and duration of drought
- long-term probability of hydroclimate conditions exceeding specific thresholds
- a context for scenarios of water supply under climate change
- a much broader perspective on the variability of water levels to assess the reliability of water supply systems under a wider range of flows than recorded by a gauge
- the geographic extent of multi-year periods of low-and-high flows, including the synchroneity of droughts

Spring 1796, Edmonton House

At Edmonton House, a large fire burned "all around us" on April 27th (1796) and burned on both sides of the river. On May 7th, light canoes arrived at from Buckingham House damaged from the shallow water.



Timber intended to be used at Edmonton House could not be sent to the post "for want of water" in the North Saskatchewan River. On May 2nd, William Tomison wrote to James Swain that furs could not be moved as, "there being no water in the river." (Johnson 1967: 33-39, 57)

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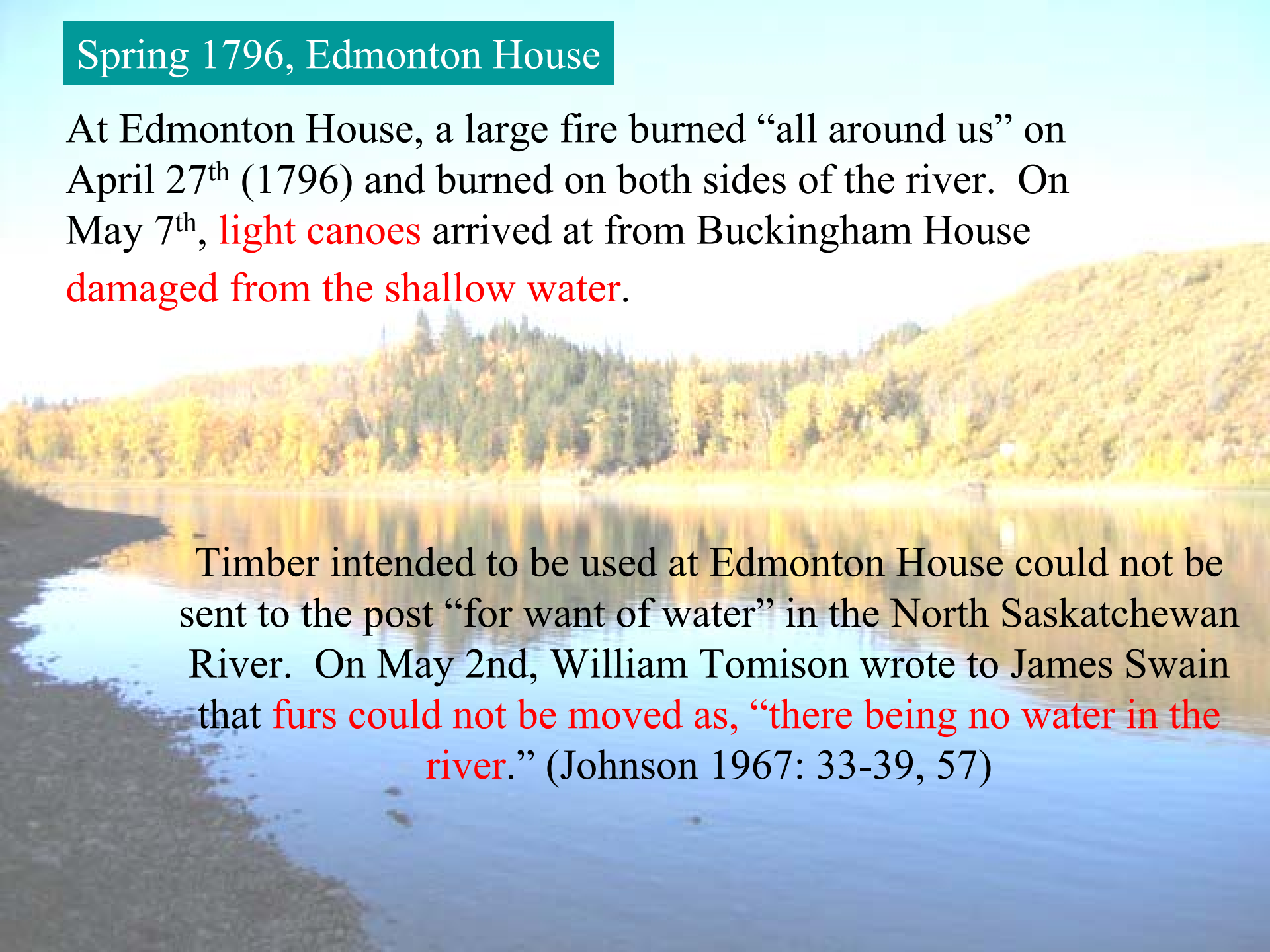

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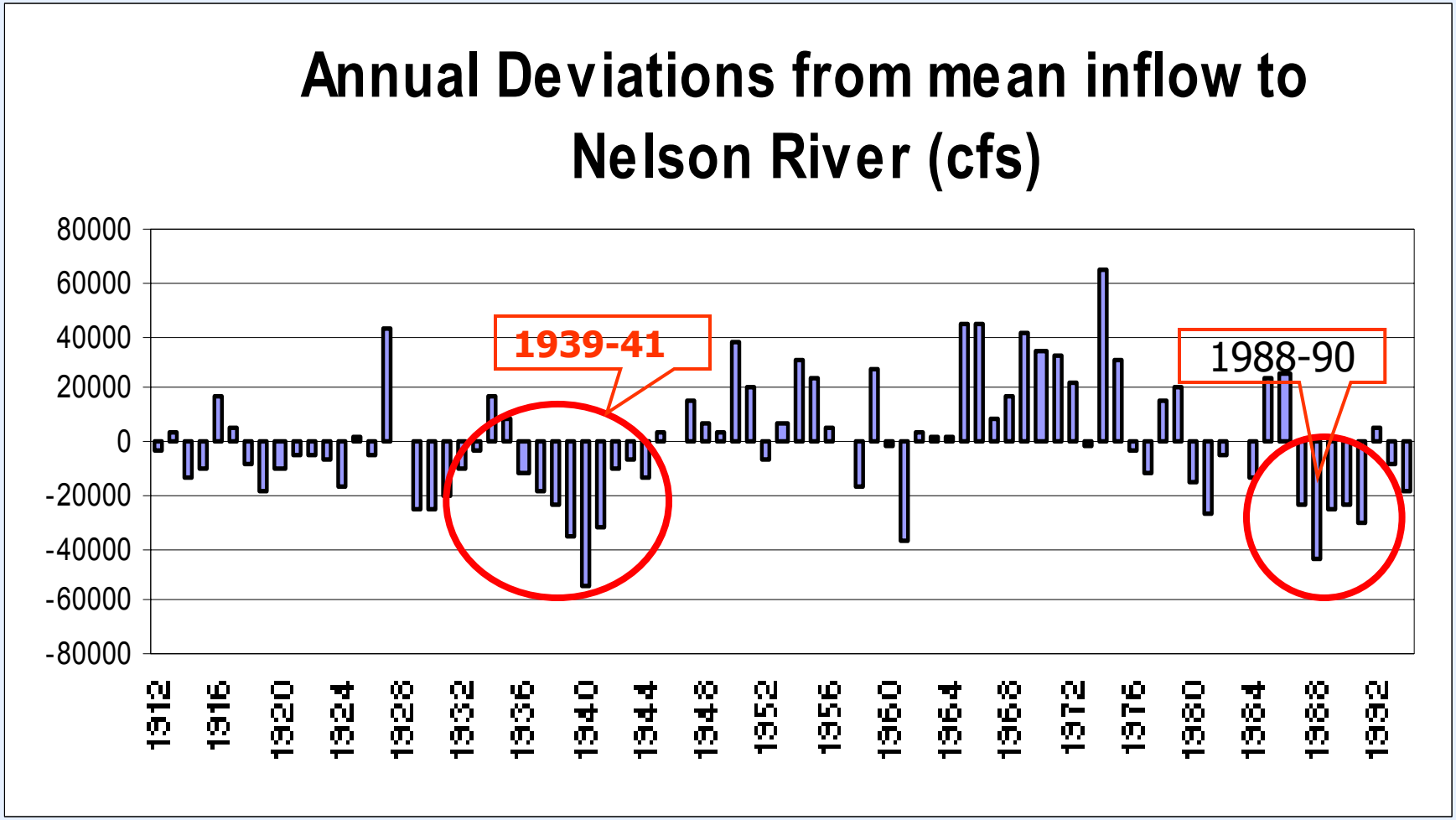
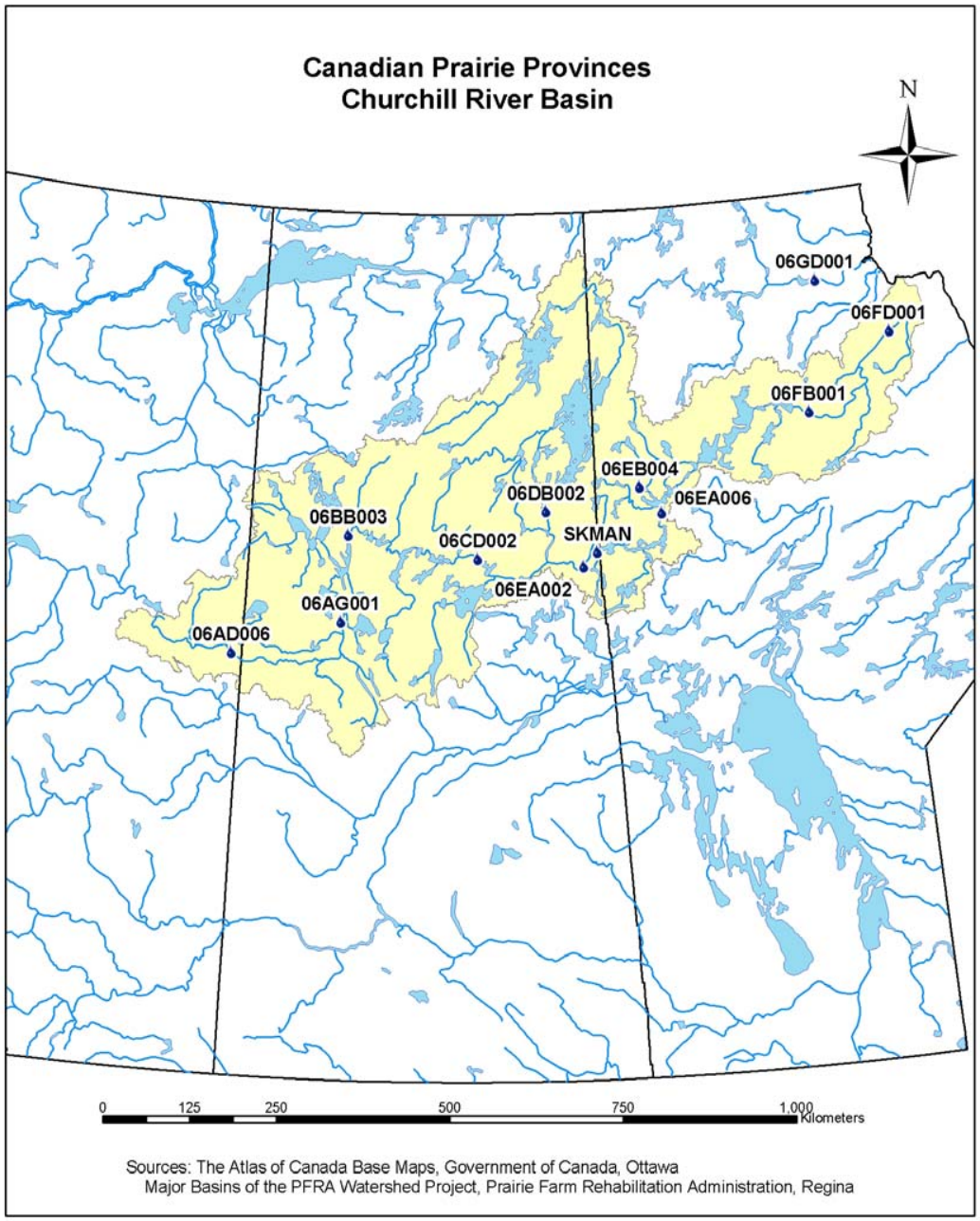
MB Hydro Watershed, Drought of Record

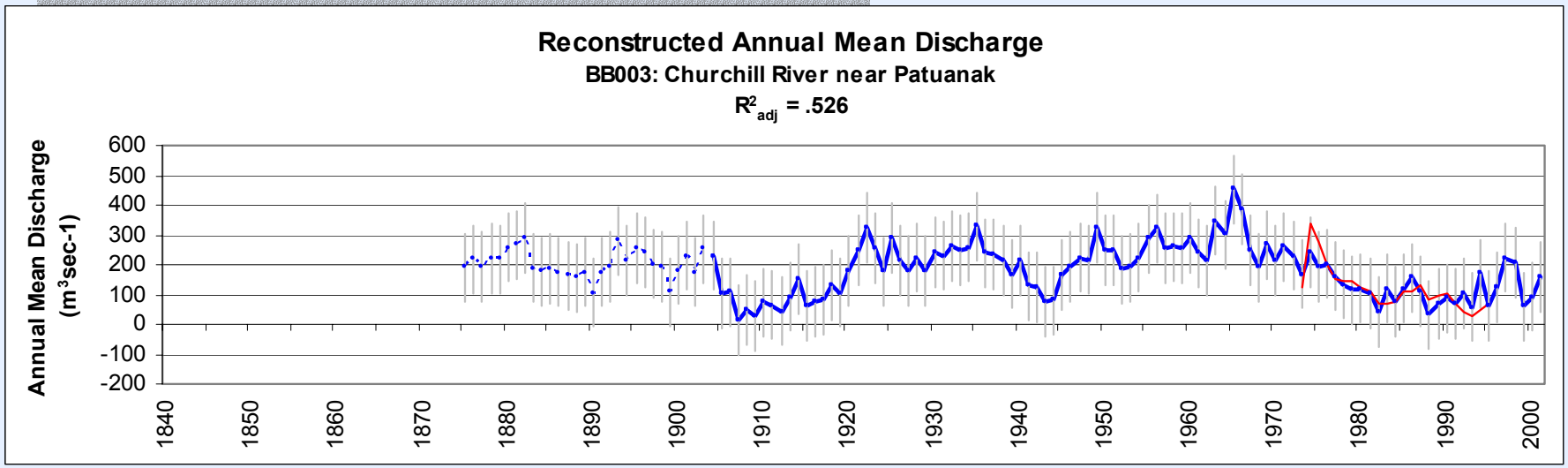


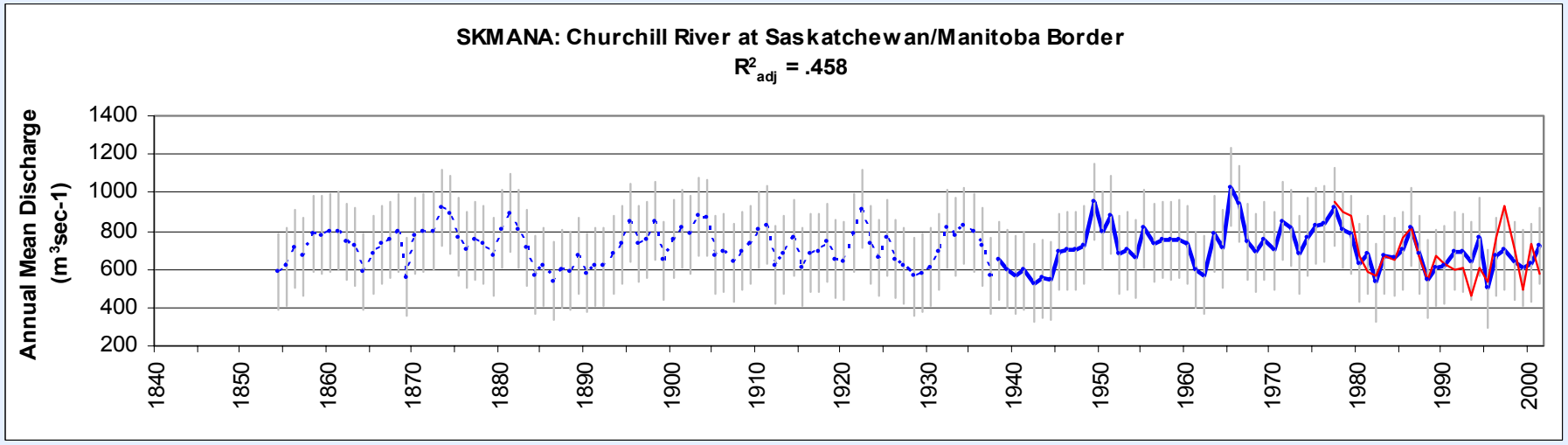

Canadian Prairie Provinces
Churchill River Basin
N
06GD001
06FD001
06FB001
06EB004
06DB002
06EA006
06BB003
06CD002
SKMAN
06EA002
06AG001
06AD006
0
125
250
500
750
1,000
Kilometers
Sources: The Atlas of Canada Base Maps, Government of Canada, Ottawa
Major Basins of the PFRA Watershed Project, Prairie Farm Rehabilitation Administration, Regina

Tree-Ring Models of Streamflow, Churchill River Basin

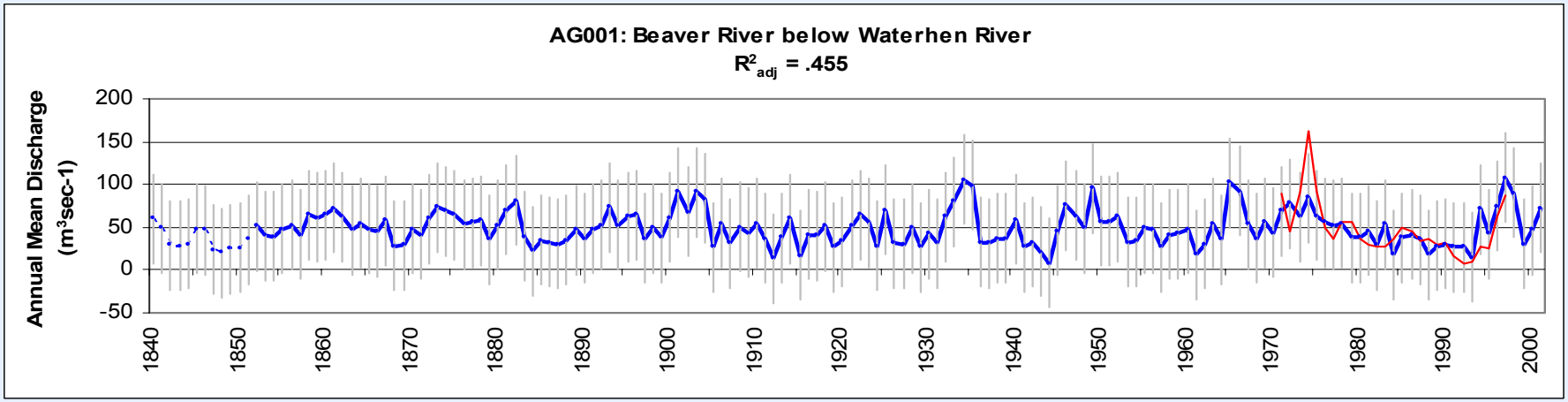
GAUGE	PREDICTORS	RE	R^2_{ADJ}	$RMSE_V$	SE_E
BB003W	KI_ARS, IL_ARS	0.33	0.526	57.48	49.54
SKMANA	PC_ARS	0.42	0.458	100.90	99.14
AG001A	KI_ARS	0.34	0.455	26.07	24.17
SKMANA	BG_ARS	0.36	0.404	105.36	103.95
EB004A	PC_ARS	0.35	0.404	140.34	137.08

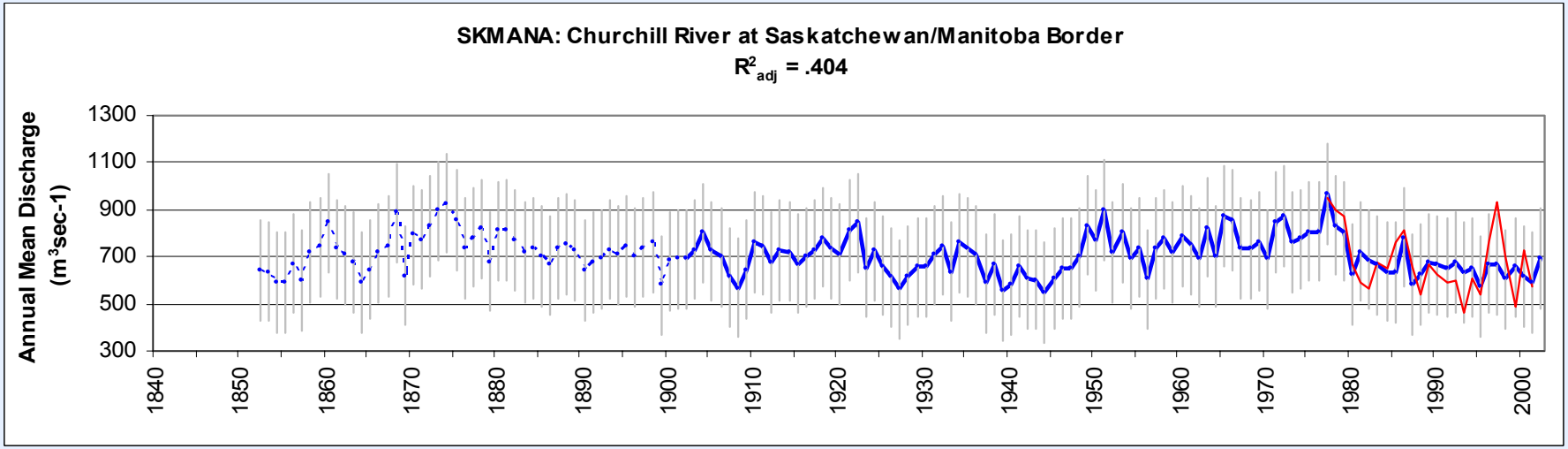
Streamflow Reconstructions, Churchill River Basin

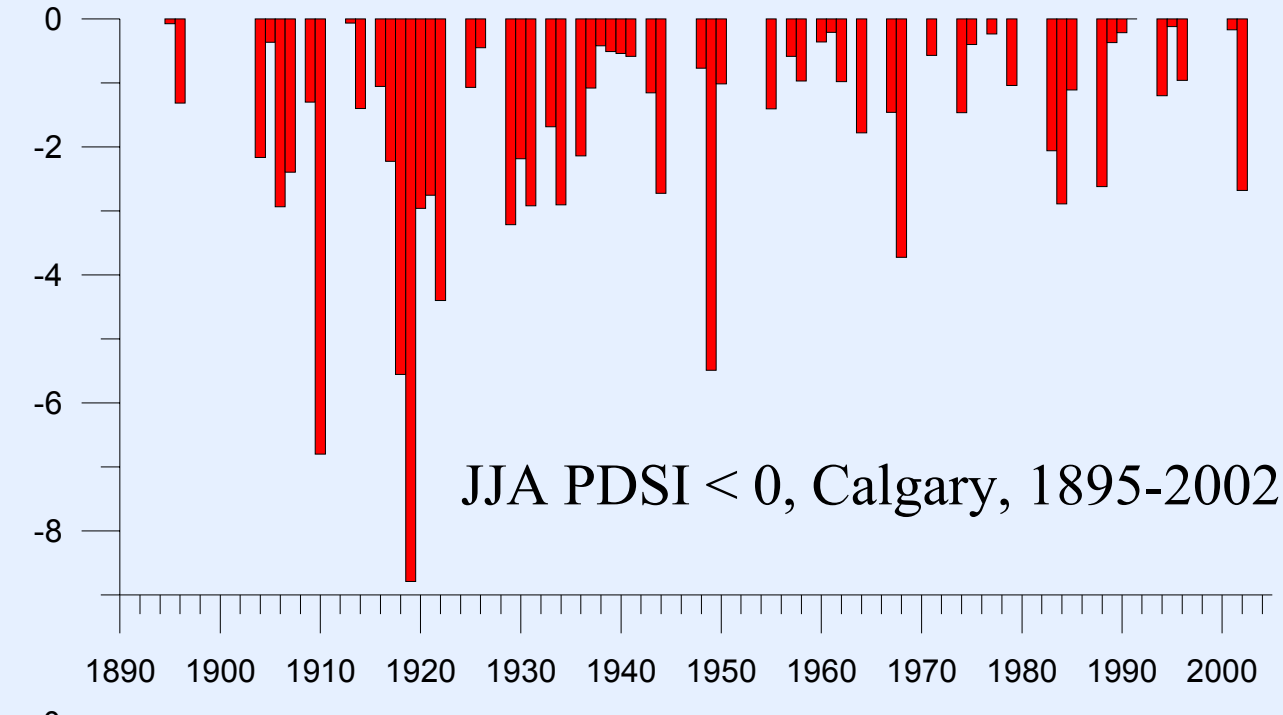




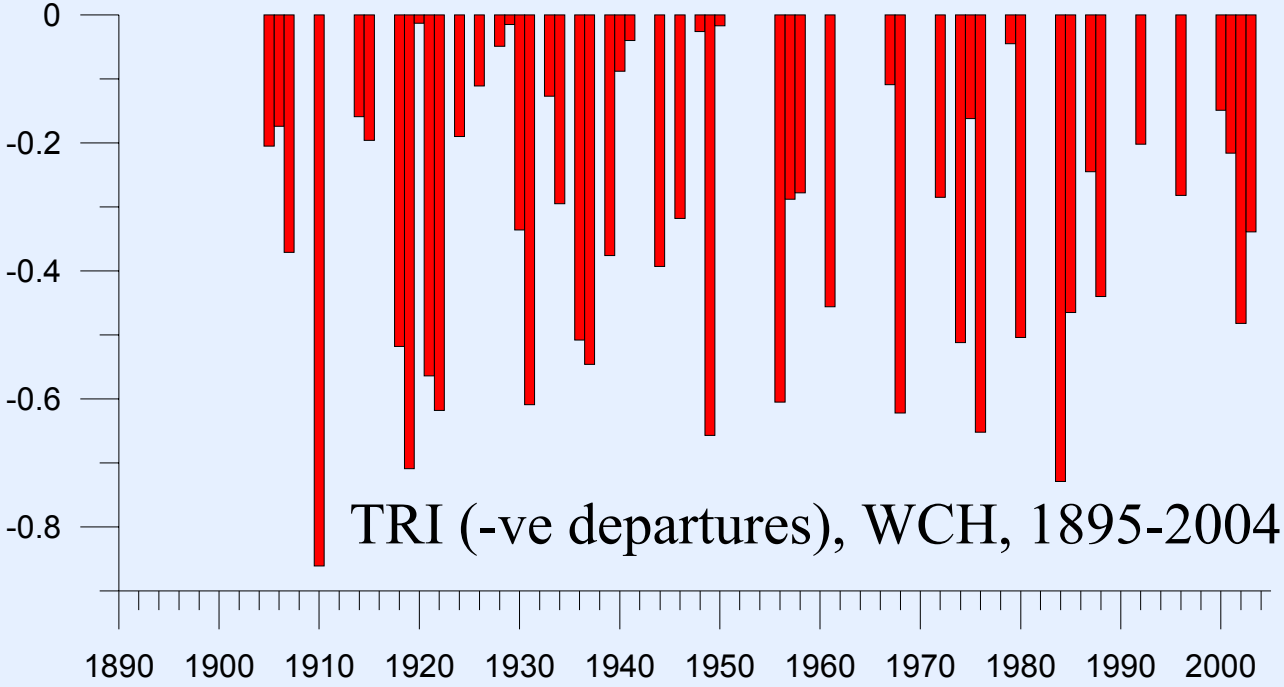
Streamflow Reconstructions, Churchill River Basin



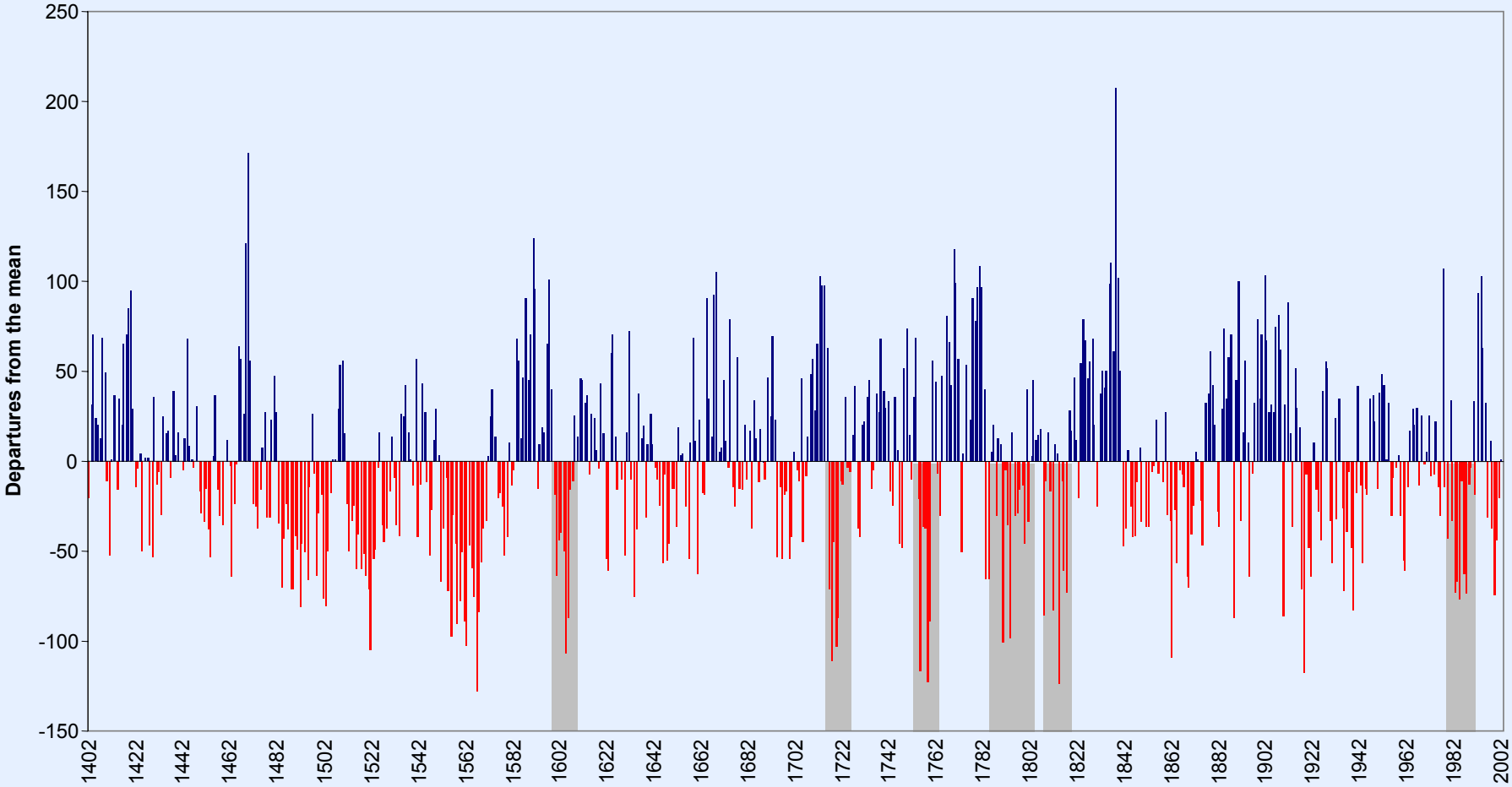



0
-2
-4
-6
-8
JJA PDSI < 0, Calgary, 1895-2002
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

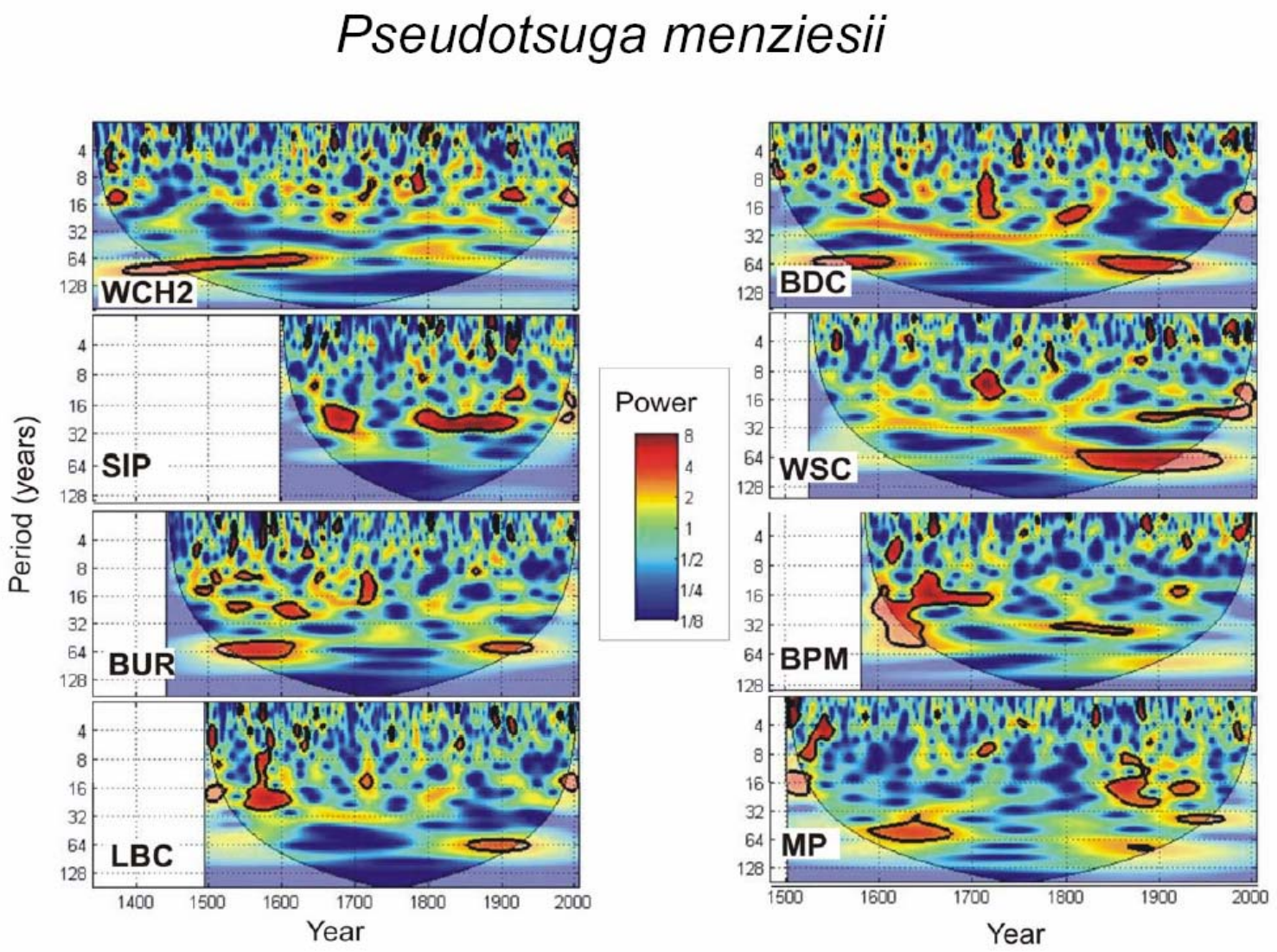
r = 0.628

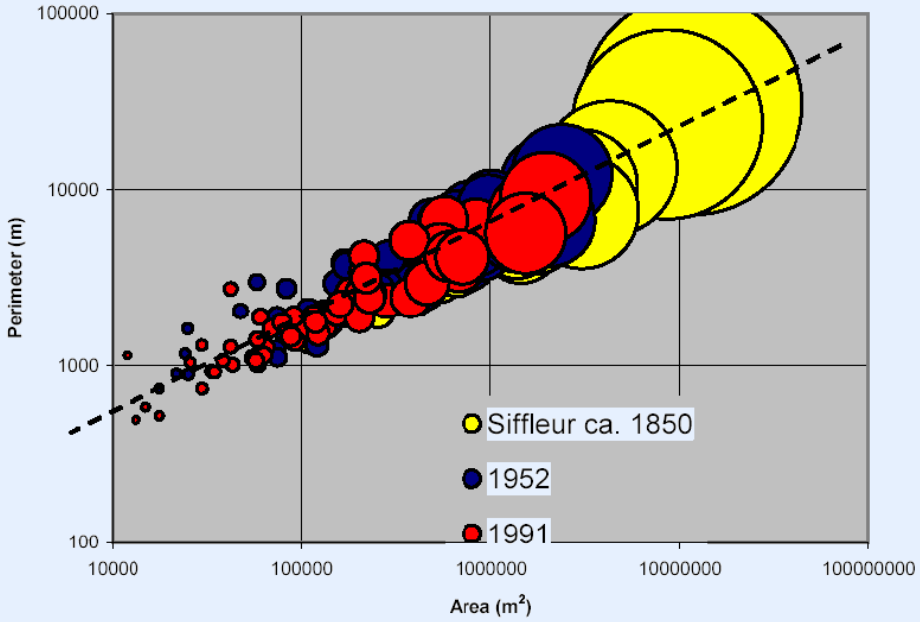

0
-0.2
-0.4
-0.6
-0.8
TRI (-ve departures), WCH, 1895-2004
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

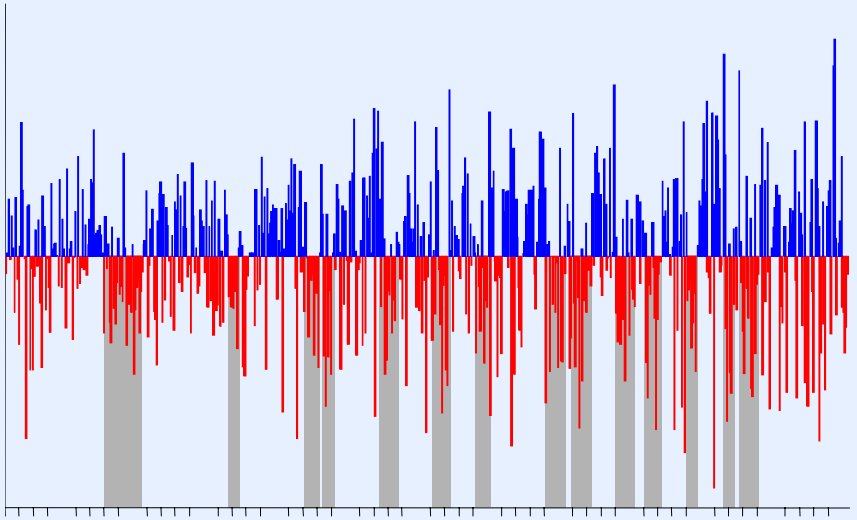
South Saskatchewan River at Medicine Hat, 1402-2004

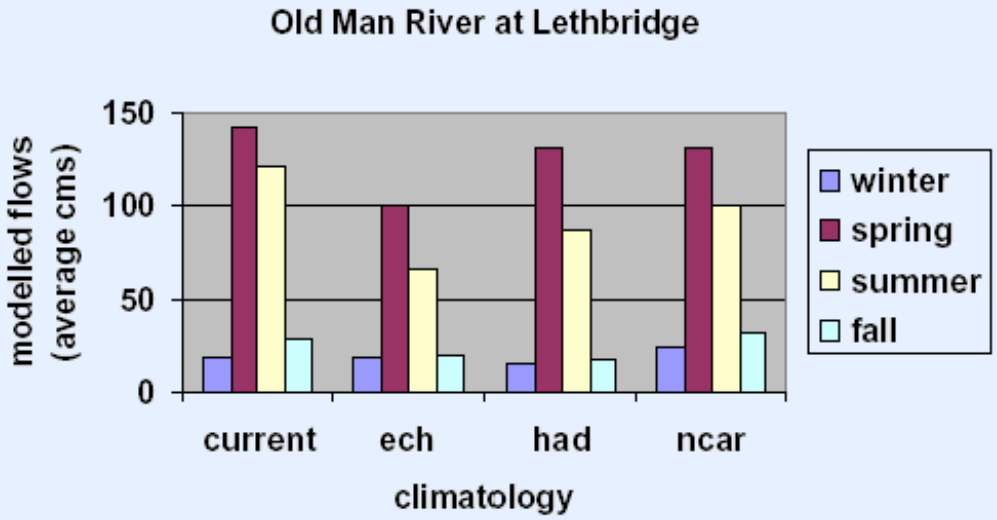


Wavelet power spectra



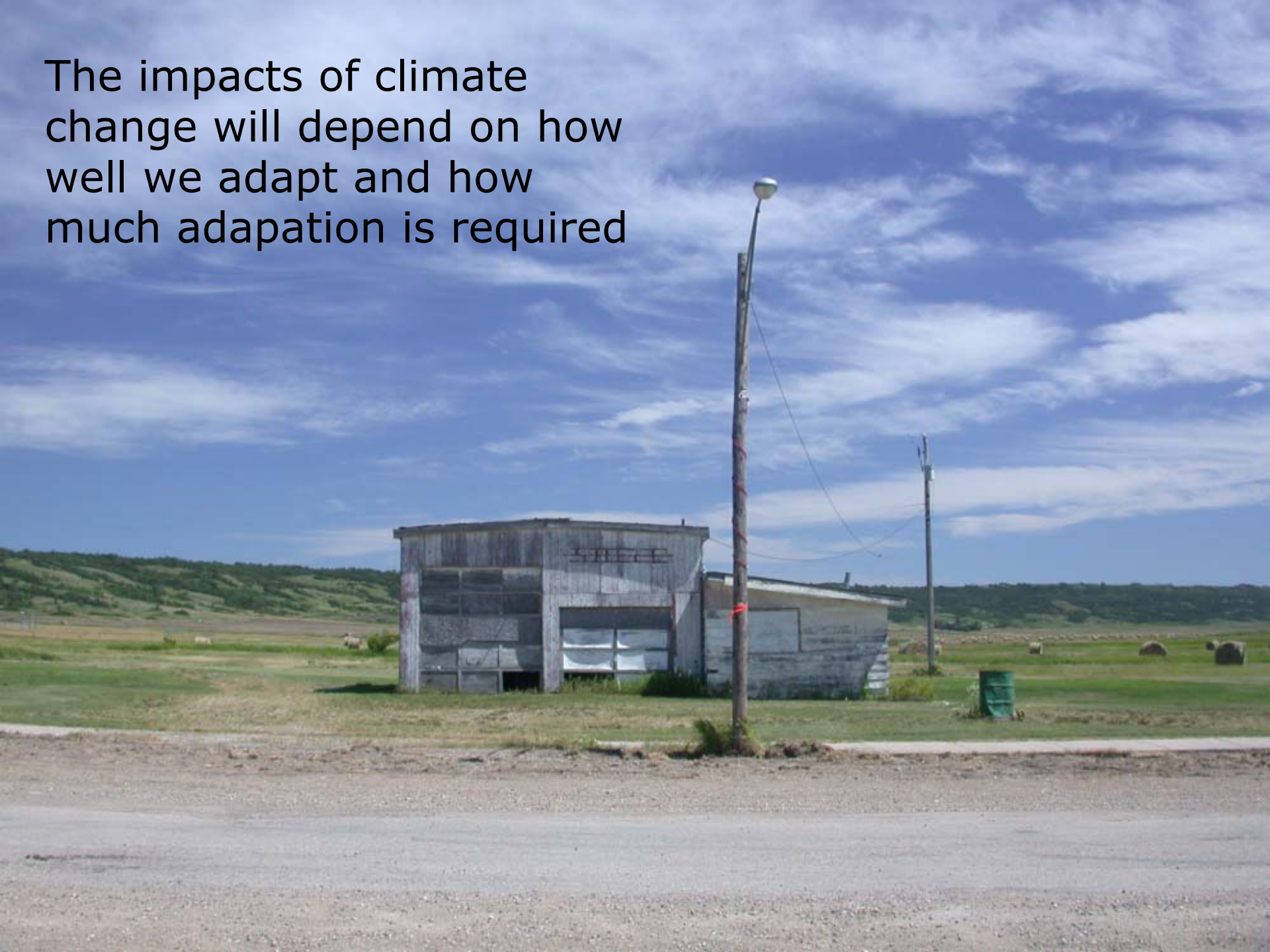




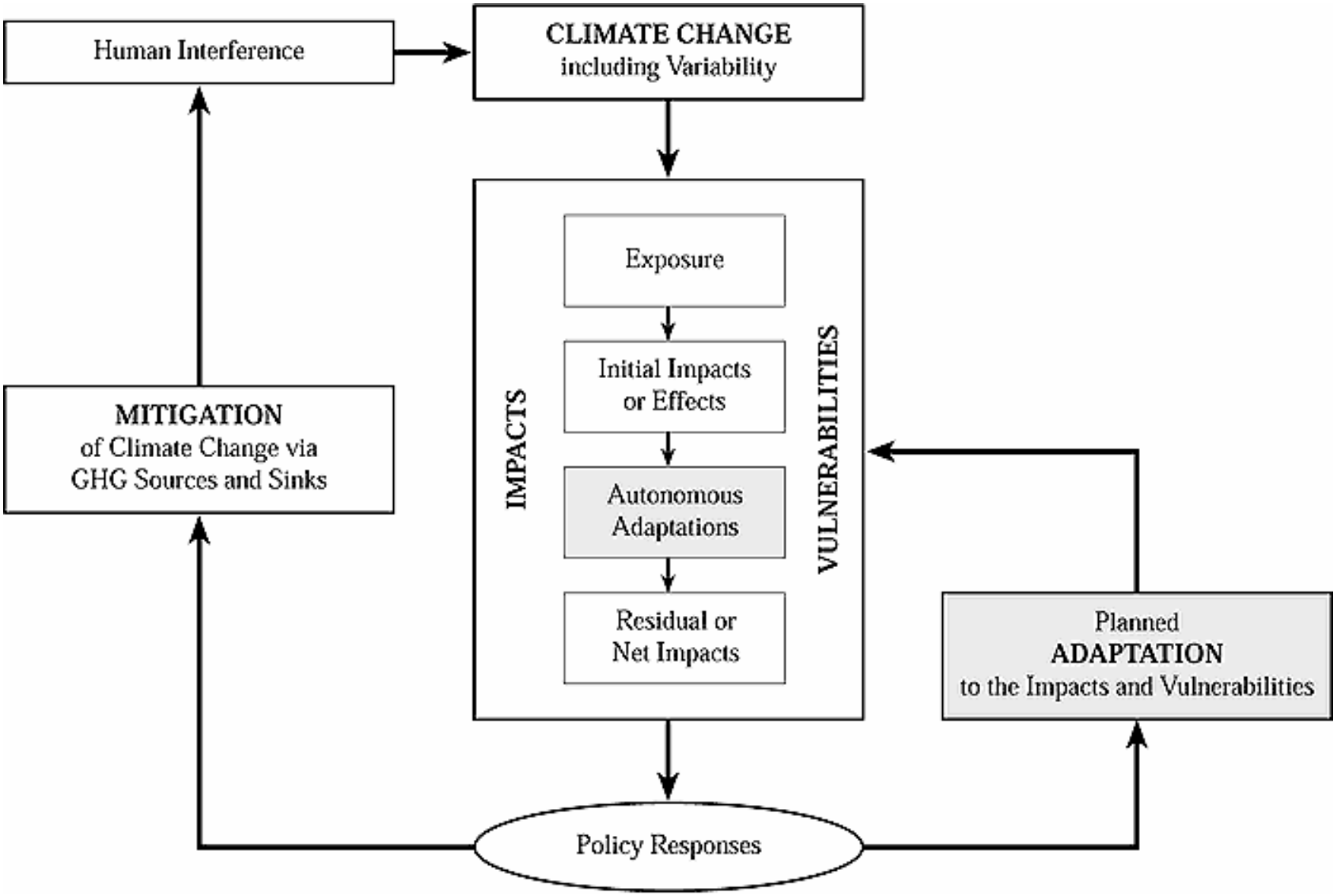


A "myth of abundance" and an explicit assumption that "the hydrological regime is stationary and will continue to be stationary in the future".

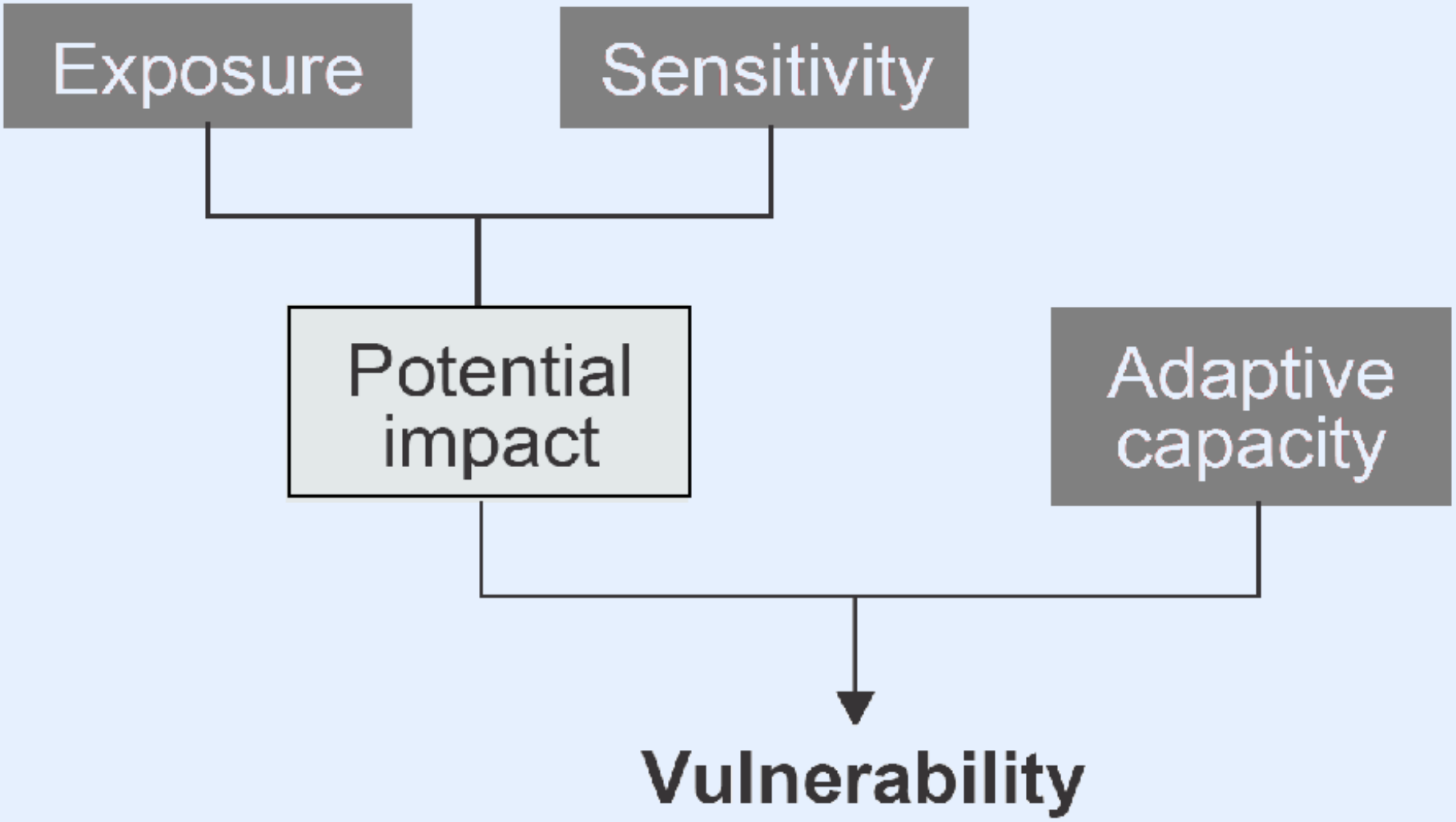
Most impacts are adverse because economies and activities are not adapted to change


The impacts of climate change will depend on how well we adapt and how much adapation is required

Policy Responses



Determinants of Vulnernability (Risks and Opportunities)



Adaptive Capacity

Determinant	Explanation
Economic resources	Greater economic resources increase adaptive capacity Lack of financial resources limits adaptation options
Technology	Lack of technology limits range of potential adaptation options Less technologically advanced regions are less likely to develop and/or implement technological adaptations
Information and skills	Lack of informed, skilled and trained personnel reduces adaptive capacity Greater access to information increases likelihood of timely and appropriate adaptation
Infrastructure	Greater variety of infrastructure can enhance adaptive capacity, since it provides more options Characteristics and location of infrastructure also affect adaptive capacity
Institutions	Well-developed social institutions help to reduce impacts of climate-related risks, and therefore increase adaptive capacity
Equity	Equitable distribution of resources increases adaptive capacity Both availability of, and access to, resources is important

Adaptation

Adjustments in practices, processes, or structures of systems to projected or actual changes of climate (IPCC, 2001).

Does change cost?

- Are we optimal?
- Natural systems – conservation of mass and energy
- Human systems – 15% used, 85% wasted
- Maybe we are outrageously imperfect?
- Maybe change pays?

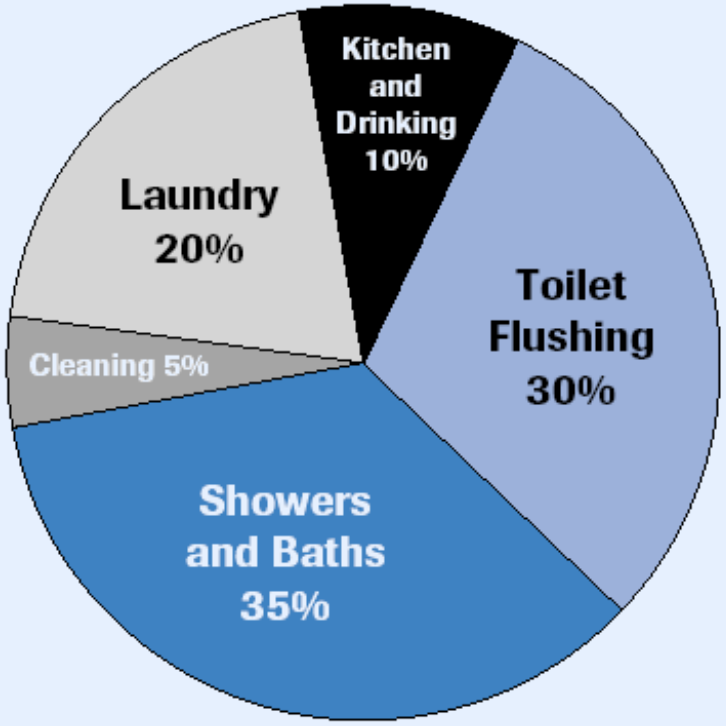

Okanagan River Restoration Initiative
Nemes-Lougheed Re-Meandering Site 2006
Newbury Hydraulics
Wild Earth Photography 2006

Programs & Services
Welcome to Regina
Doing Business
Parks & Recreation
City Hall

Water Conservation

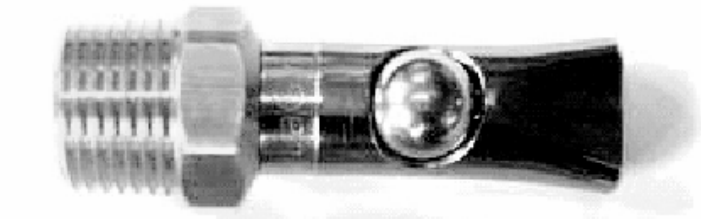
The Water Conservation Program was established in 1988 to reduce water consumption in the city and delay the need for a $40 million expansion of the water treatment plant. Each summer, when demand for water is highest, the program sponsors a public awareness campaign. During other times in the year, the City offers an informative display at the Home and Garden Show, **free xeriscape workshops** and water conservation tips on water bills.

The program has been successful. Since the late 1980's average day water consumption has been reduced by 20%, and peak day water use is down by 25%.

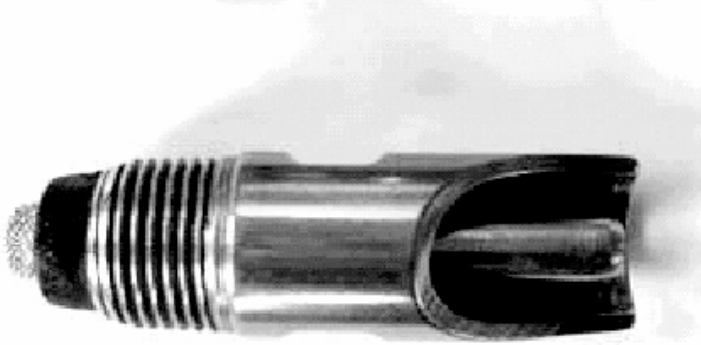


JV Farms, High River, Alberta

ball-bite drinker



standard drinker



- one-year trial, from August 2004 to July 2005, the ball-bite drinker sections of the barn used 35 per cent less water that the standard drinker sections
- no detrimental effects on the animals or facility management
- decrease in water usage led to many secondary benefits

Centre for Young Farmers and Sustainable Agriculture

Sustainable Agriculture

Sustainable agriculture refers to an agricultural production and distribution system that:

- Achieves the **integration** of natural biological cycles and controls,
- Protects and renews **soil** fertility and the natural resource base,
- Optimizes the management and use of **on-farm** resources,
- **Reduces** the use of nonrenewable resources and purchased production inputs,
- Provides an adequate and dependable farm **income**,
- Promotes **opportunity** in family farming and farm communities, and
- **Minimizes** adverse impacts on health, safety, wildlife, water quality and the environment

To achieve sustainable agriculture we must deal both with issues involving environmental impacts as well as productivity of the land. Any program to successfully develop a system of sustainable agriculture must have farmer involvement at all stages of its development, and must look at a farming system as a whole, not just at individual elements.


Thanks