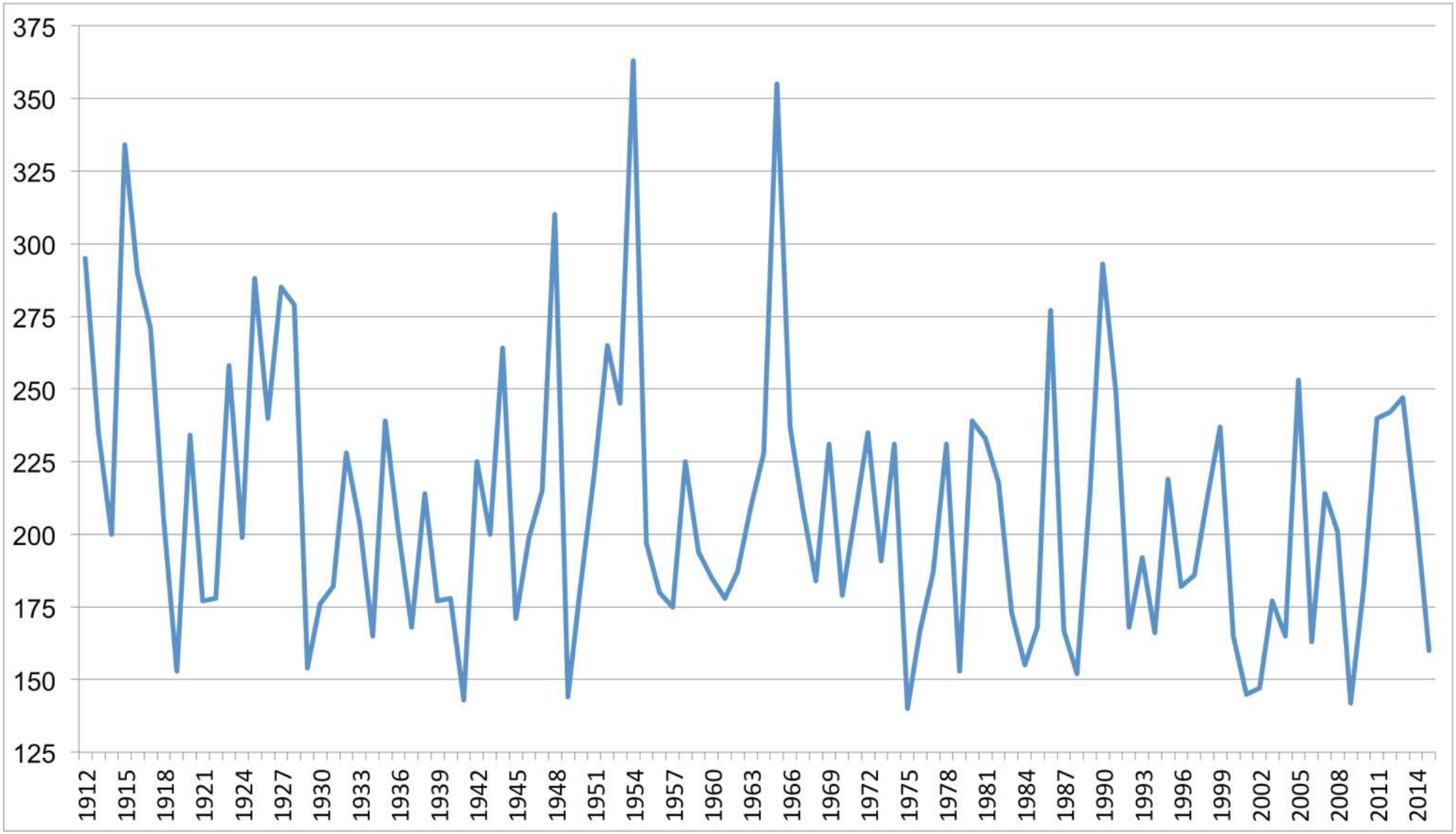
Uncertainty in Projecting Prairie Climate and Water Supplies

Dave Sauchyn, Prairie Adaptation Research Collaborative, University of Regina

ATLAS Talk, U of A, 23 March 2018

North Saskatchewan River at Edmonton
Mean Annual Year Flow (m^3/s), 1912-2015



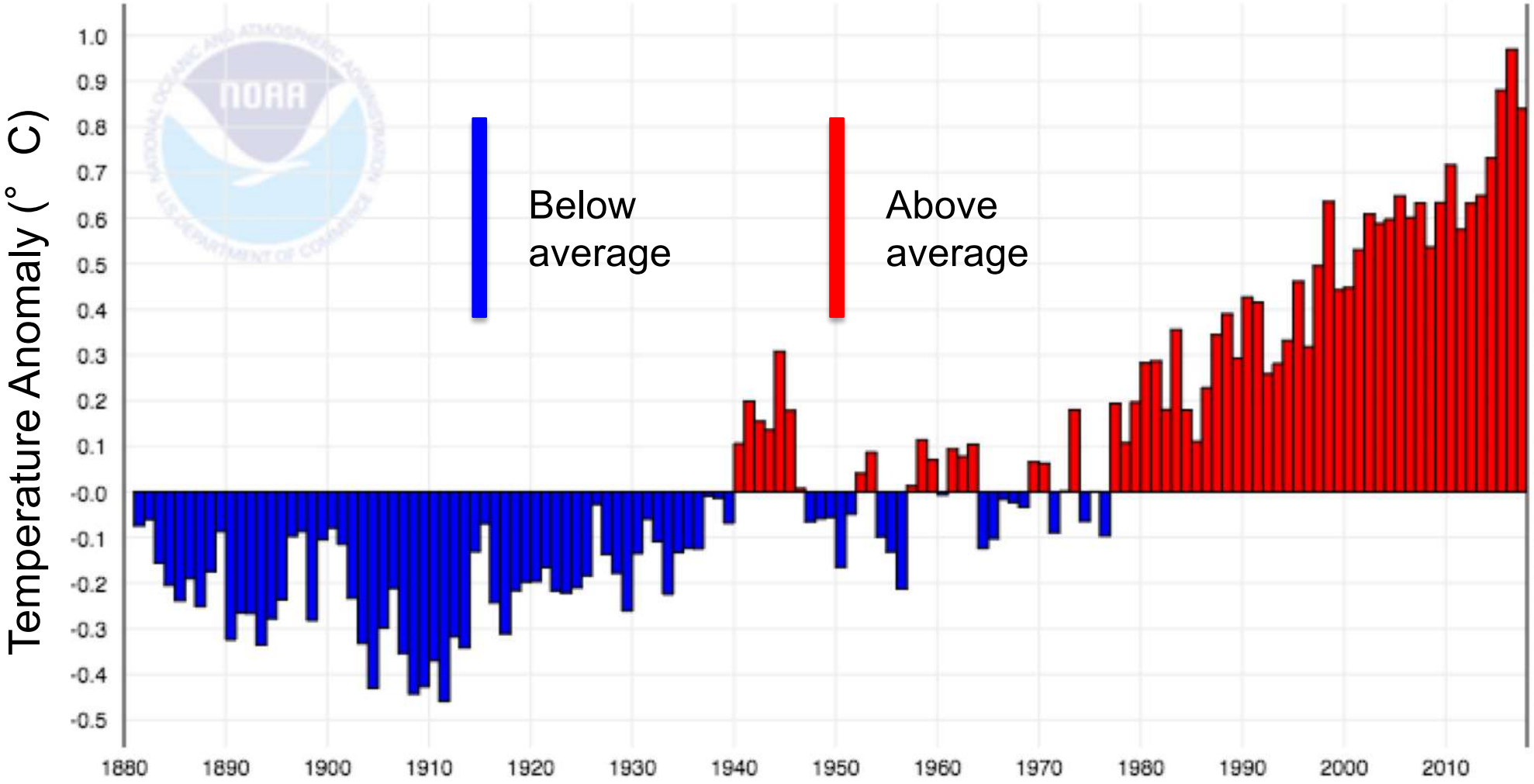
Stationarity

Despite preaching about the importance of long records, hydrologists are in fact more comfortable with short ones."
Klemeš, 1989. The improbably probabilities of extreme floods and droughts.

"Stationarity— the idea that natural systems fluctuate within an unchanging envelope of variability — is a foundational concept that permeates training and practice in water-resource engineering."
Milly, et al., 2008. Climate change: stationarity is dead: whither water management. Science.

On May 2nd [1796] William Tomison wrote to James Swain that furs could not be moved as, **“there being no water in the river.”**

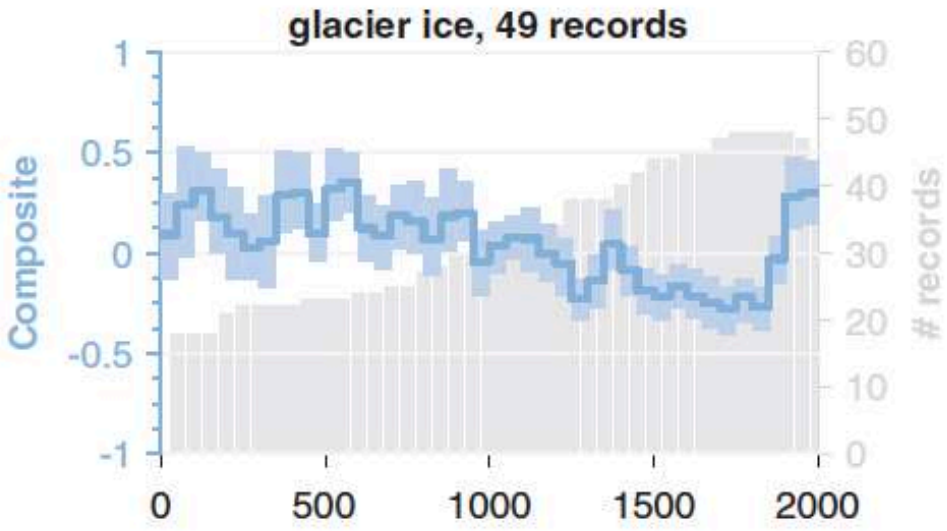
January 2018 was the **397th consecutive month** with a global temperature above the 20th century average

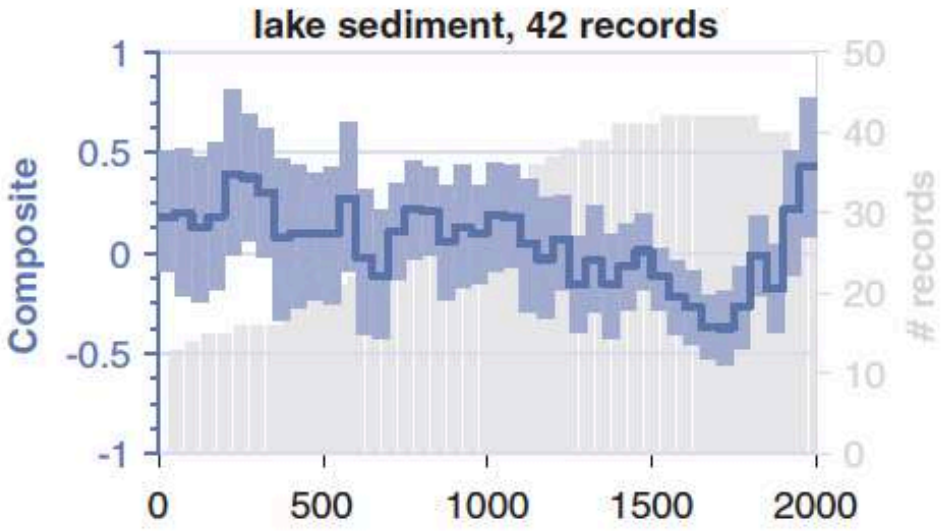


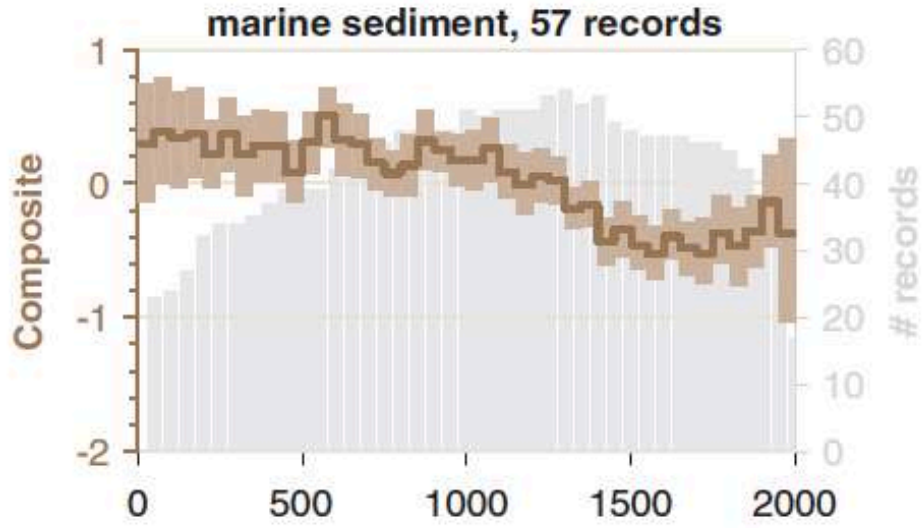
www.ncdc.noaa.gov/sotc/global/201801

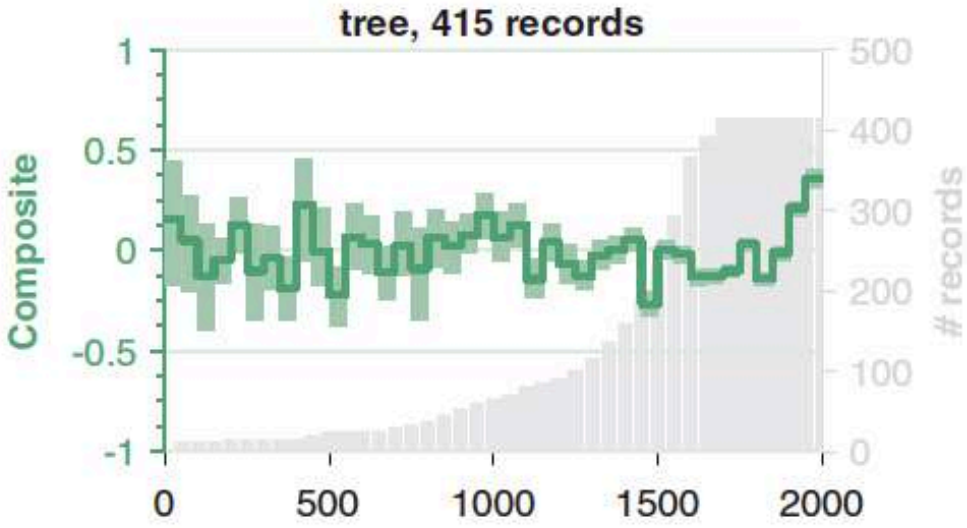

TAMARACK CHAIR
Enjoy Your Ride!
B-933
Country 95.5

PAGES2k Consortium. 2017. A global multi-proxy database for temperature reconstructions of the Common Era, *Nature Scientific Data*

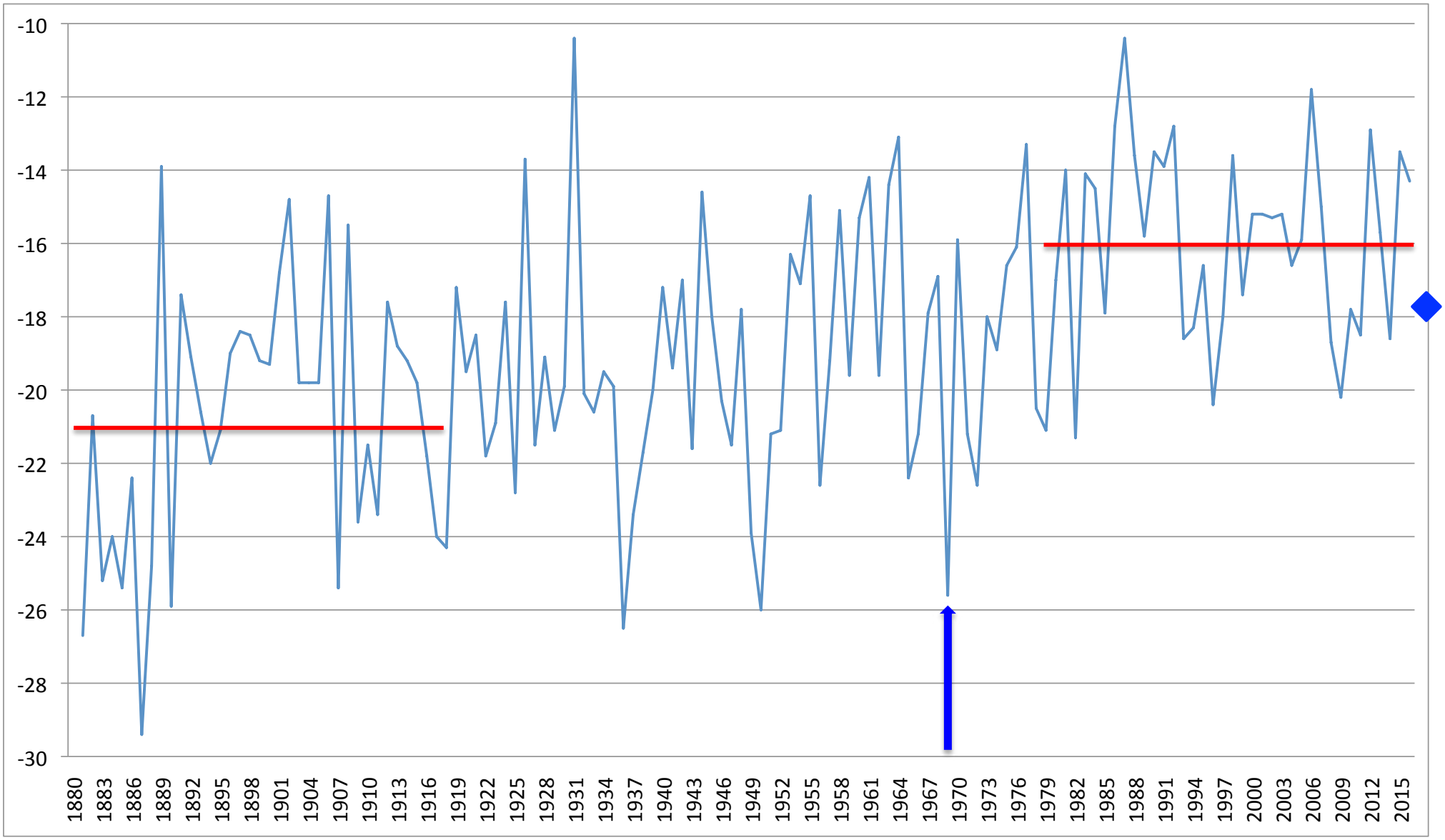








Minimum winter temperature (° C), Edmonton, 1880-2016

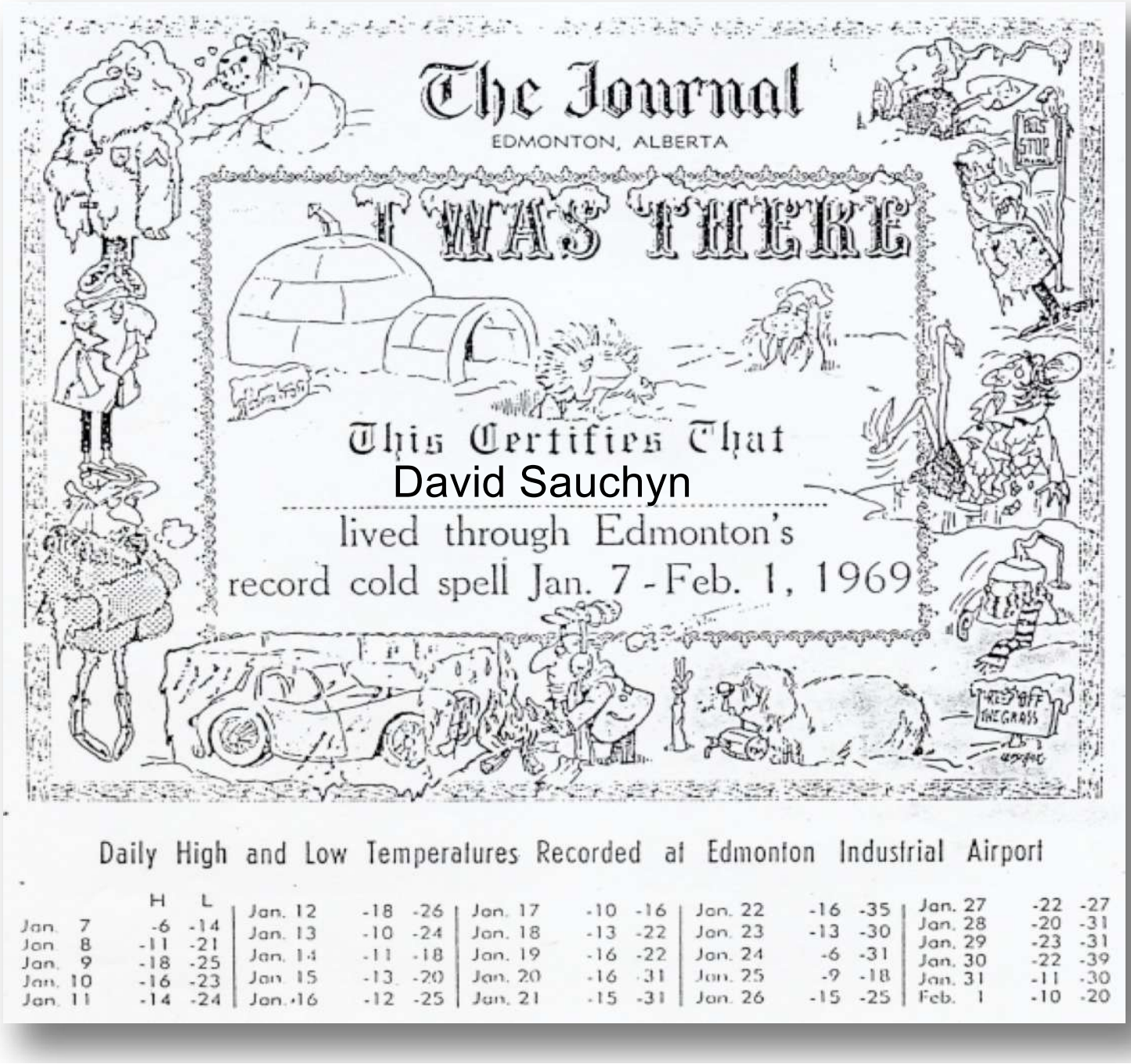


January 7 to February 1, 1969

T_{max}: - 21° C

21 days @
< - 30° C

Winter 2016:
0 days @
< - 30° C



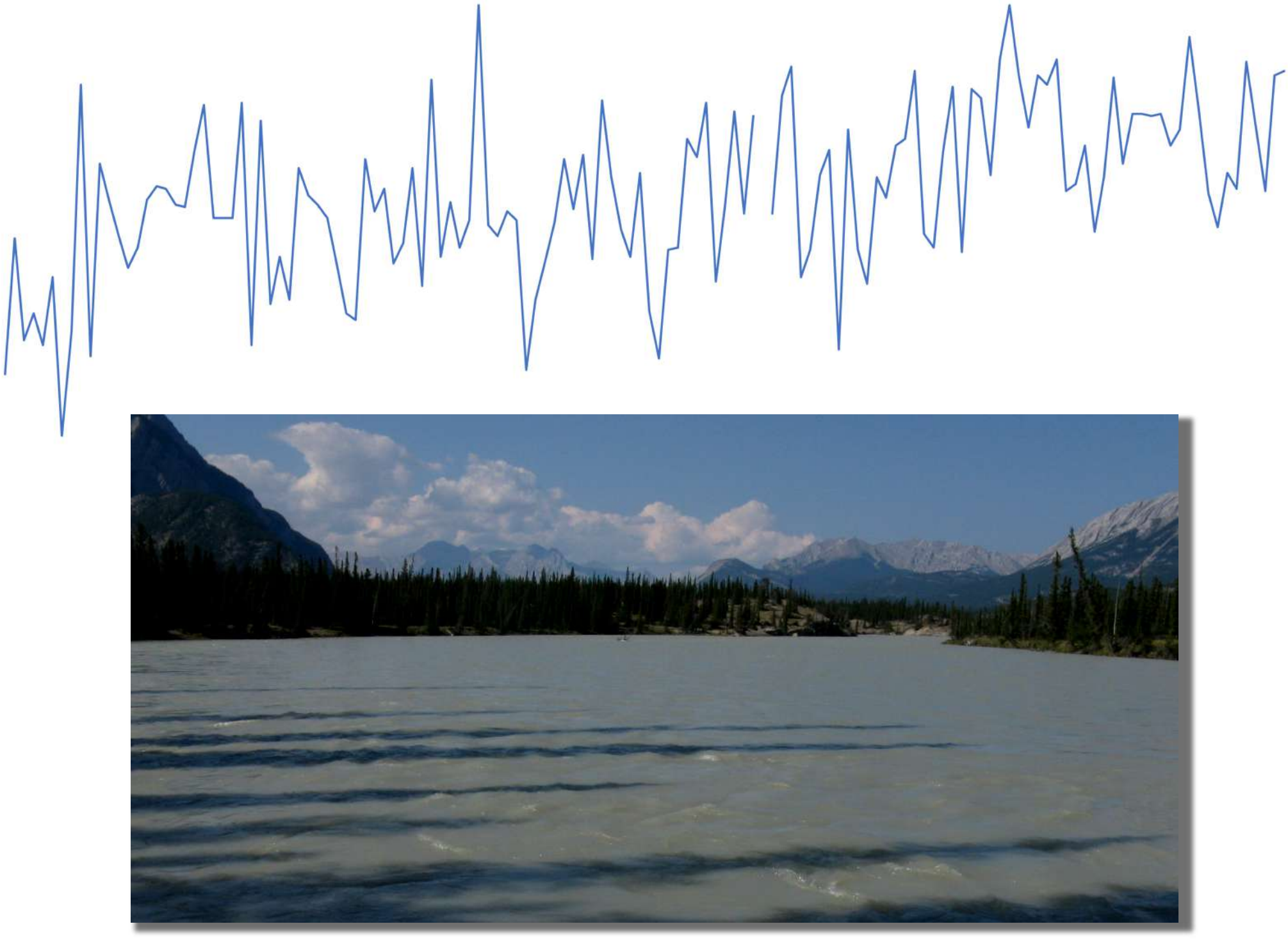
The Journal
EDMONTON, ALBERTA

'TWAS THERE

This Certifies That
David Sauchyn
lived through Edmonton's
record cold spell Jan. 7 - Feb. 1, 1969

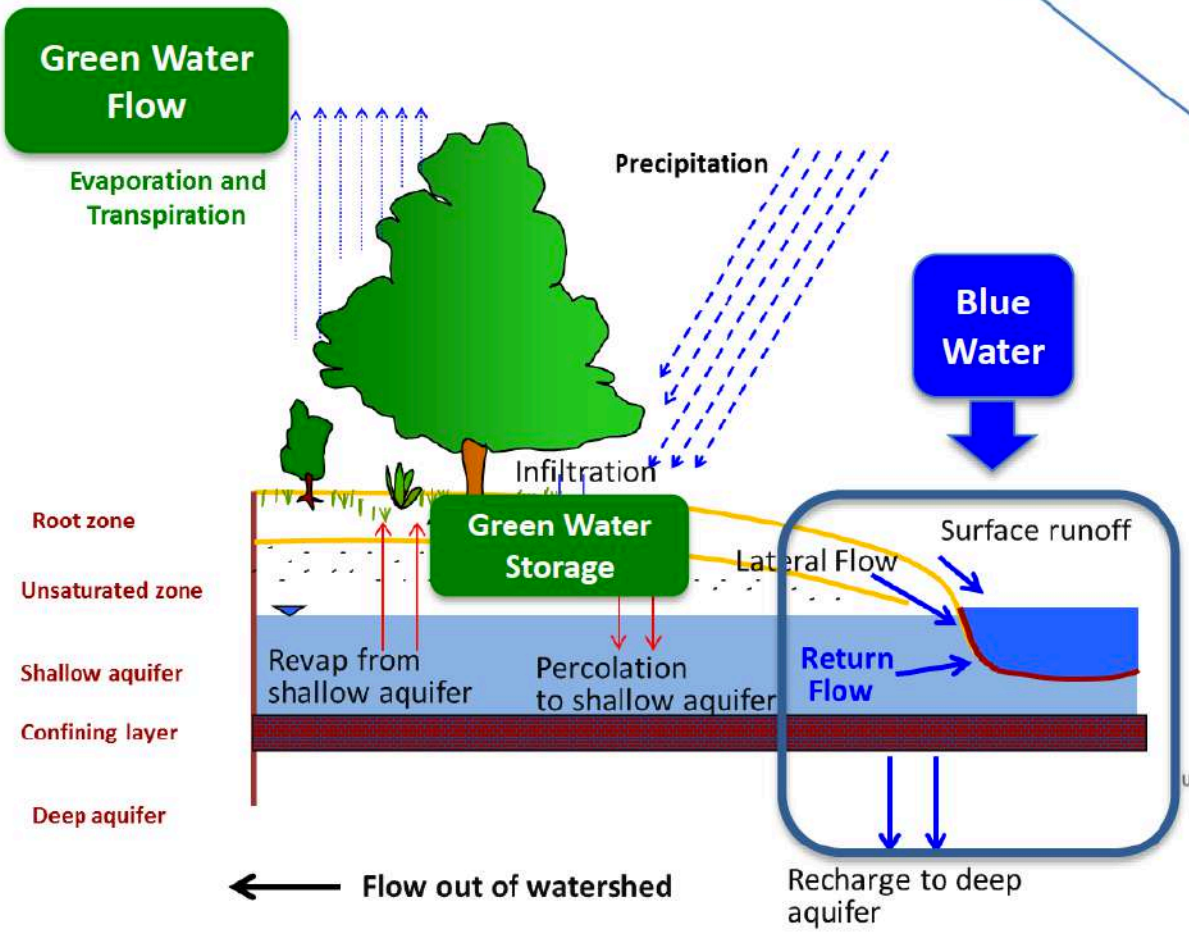
Daily High and Low Temperatures Recorded at Edmonton Industrial Airport

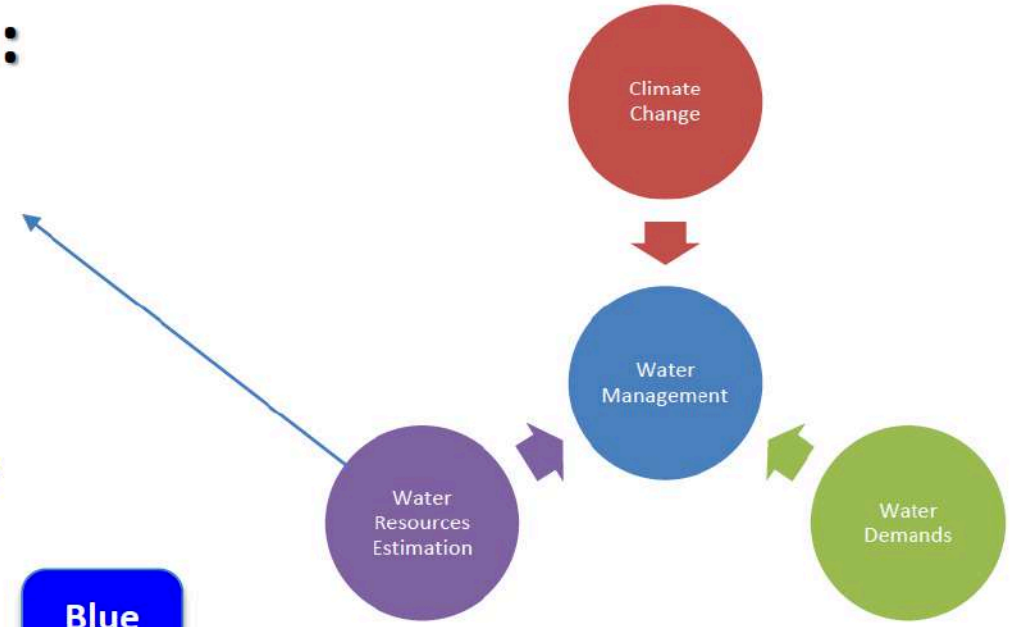
	H	L									
Jan. 7	-6	-14	Jan. 12	-18	-26	Jan. 17	-10	-16	Jan. 22	-16	-35	Jan. 27	-22	-27
Jan. 8	-11	-21	Jan. 13	-10	-24	Jan. 18	-13	-22	Jan. 23	-13	-30	Jan. 28	-20	-31
Jan. 9	-18	-25	Jan. 14	-11	-18	Jan. 19	-16	-22	Jan. 24	-6	-31	Jan. 29	-23	-31
Jan. 10	-16	-23	Jan. 15	-13	-20	Jan. 20	-16	-31	Jan. 25	-9	-18	Jan. 30	-22	-39
Jan. 11	-14	-24	Jan. 16	-12	-25	Jan. 21	-15	-31	Jan. 26	-15	-25	Jan. 31	-11	-30
												Feb. 1	-10	-20

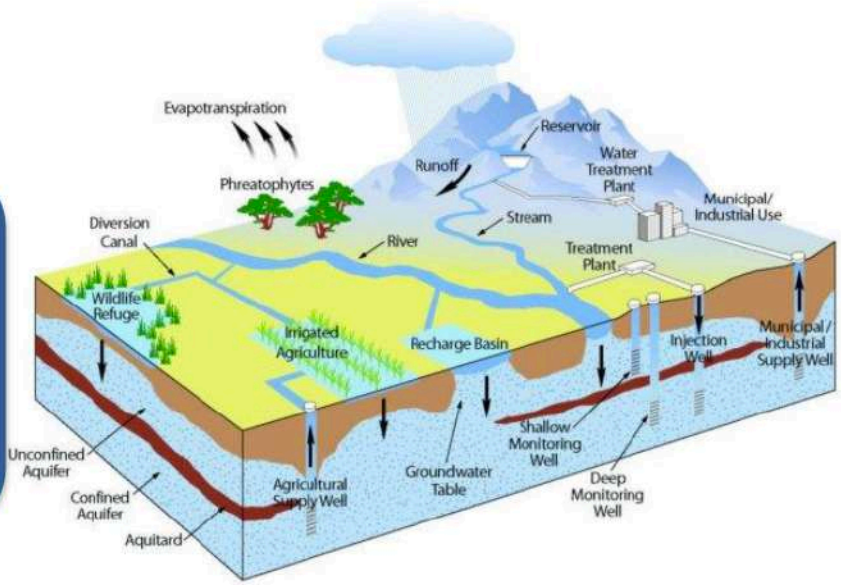


Water Resources Estimation: Hydrological model: SWAT

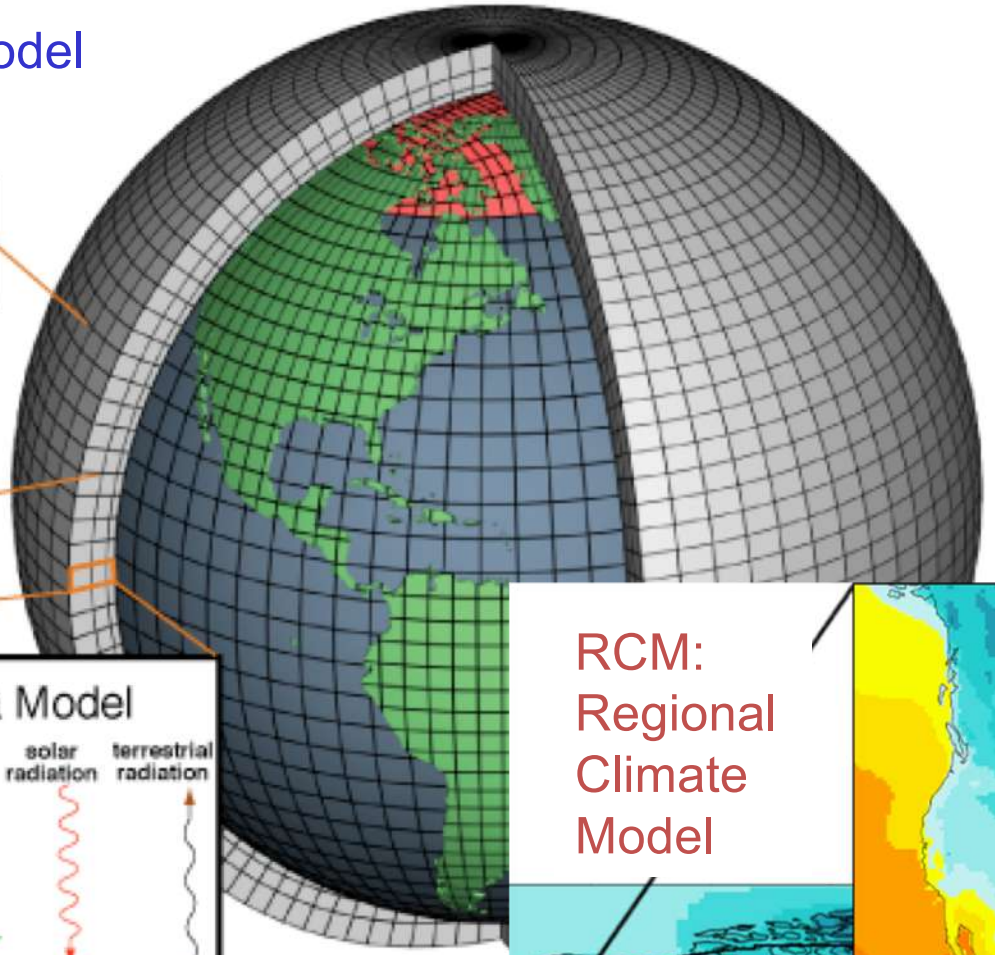
Overland processes:

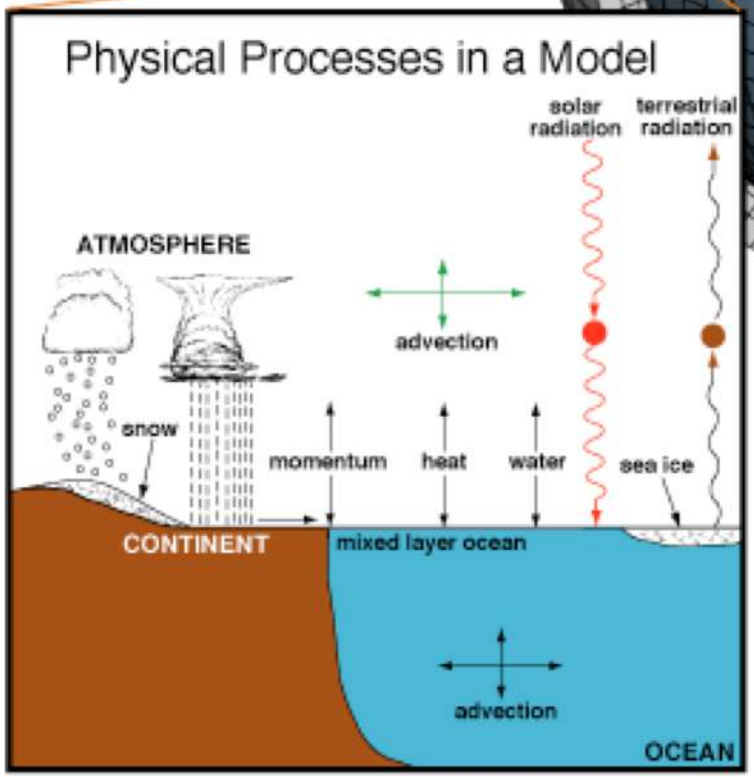




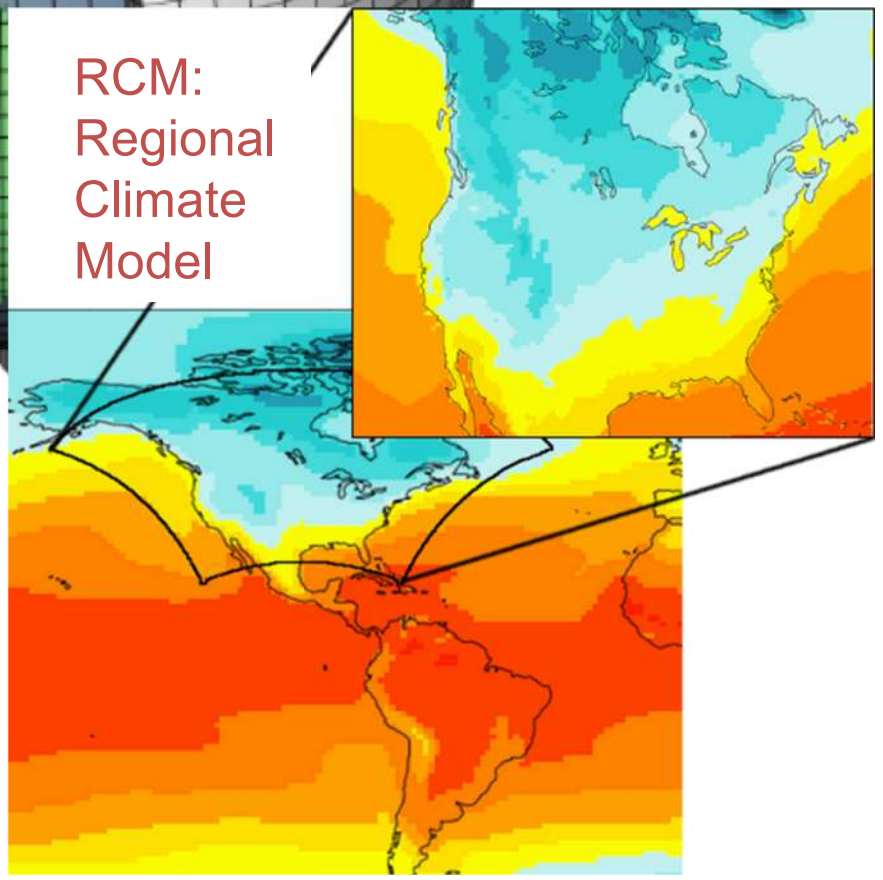


GCM: Global Climate Model

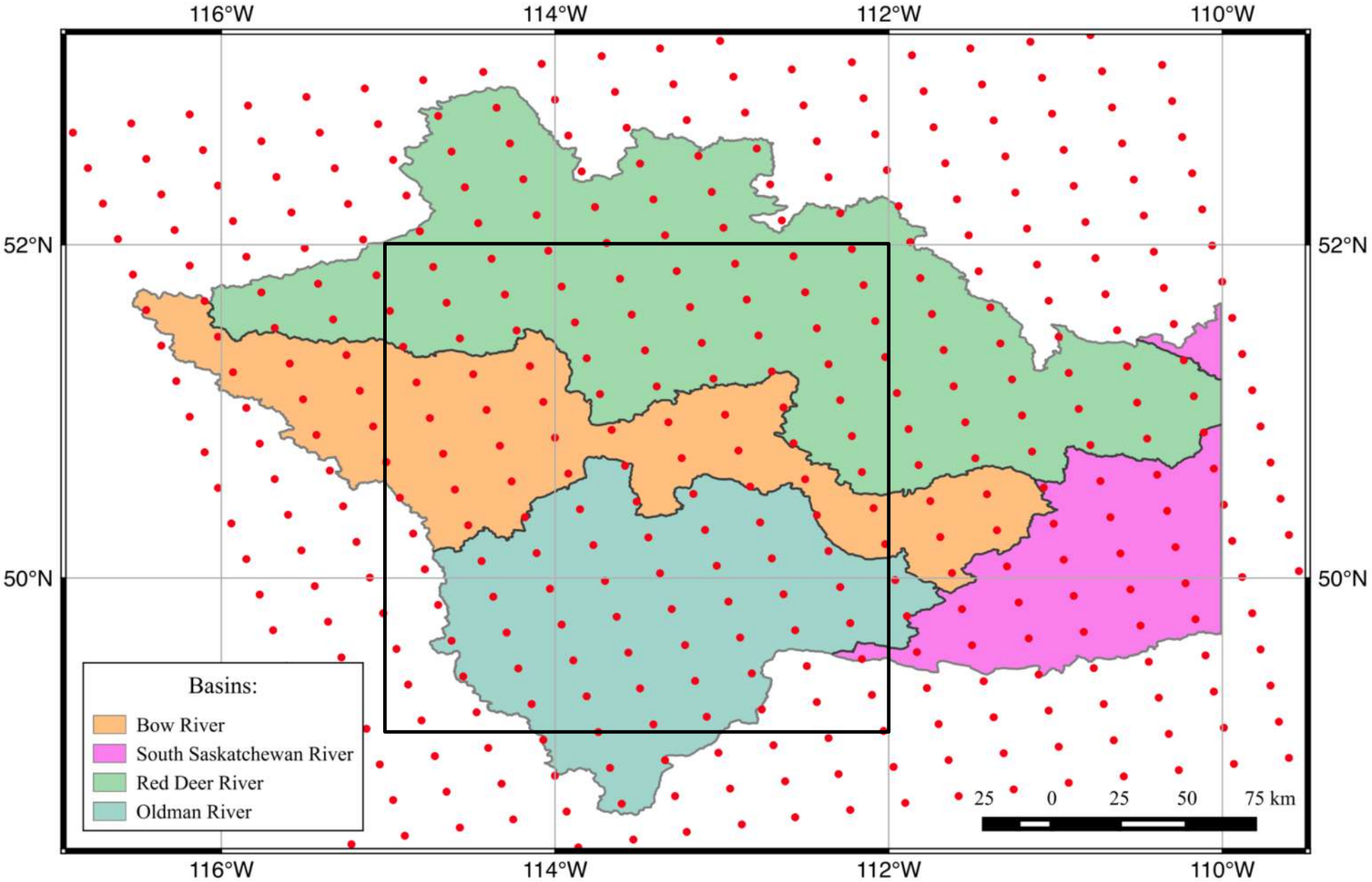




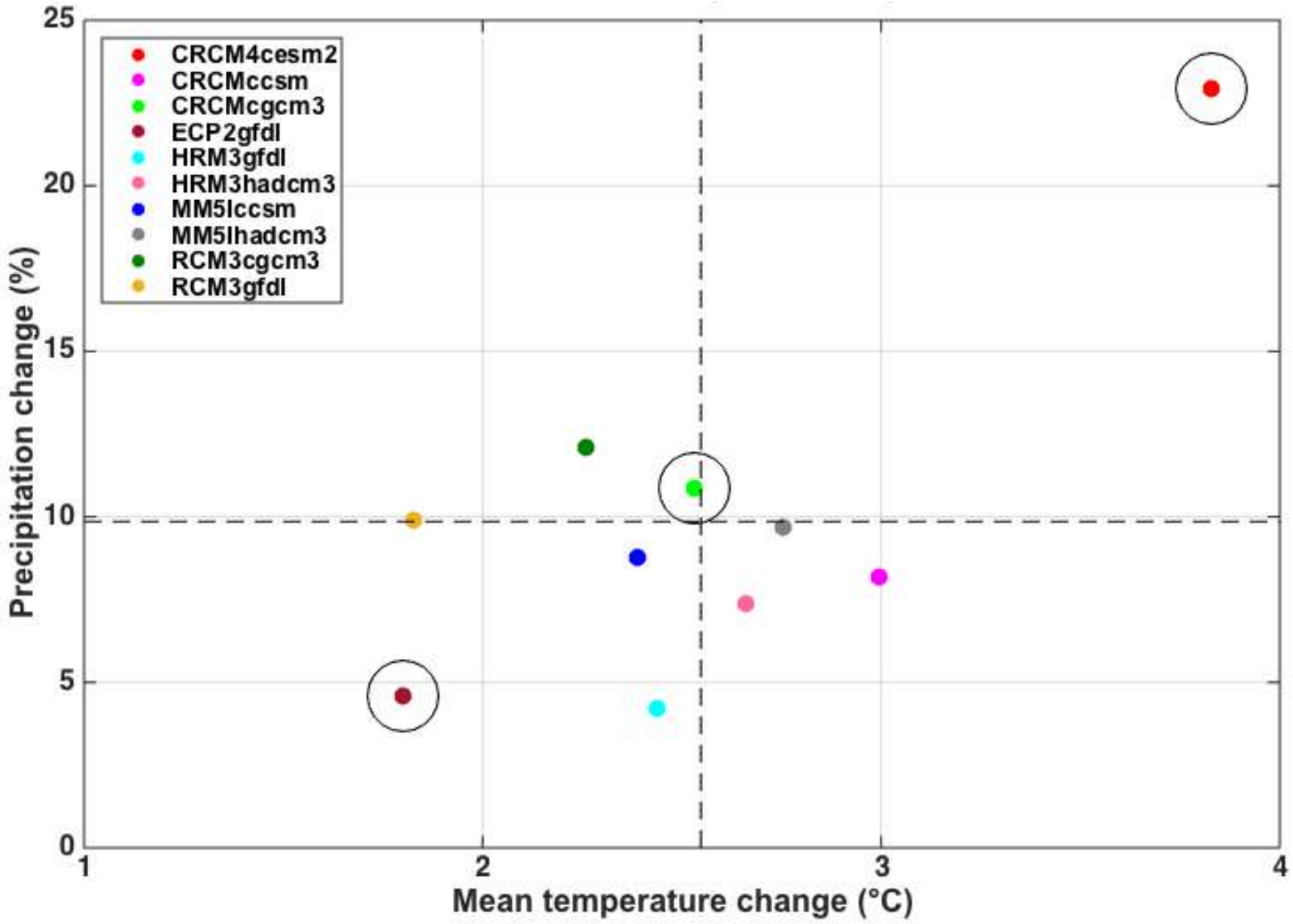
RCM: Regional Climate Model

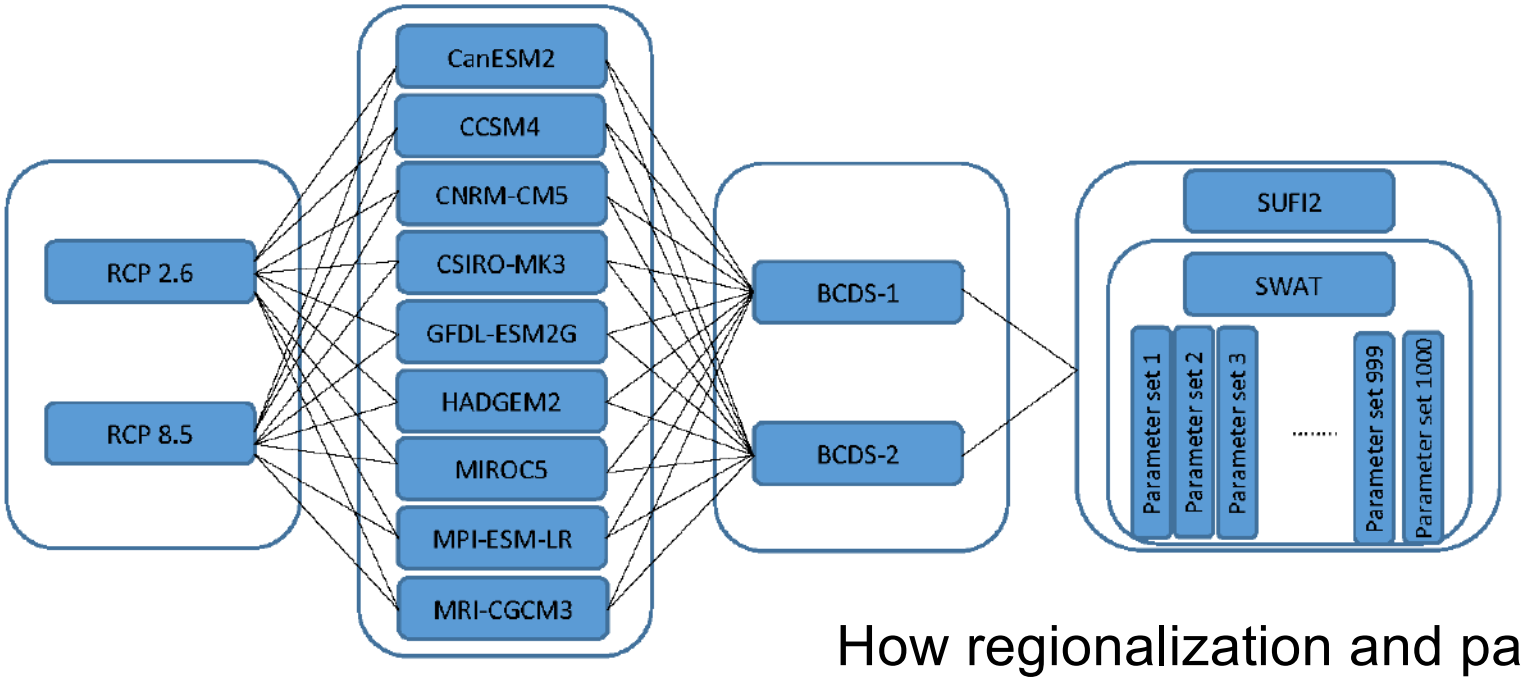


SSRB: **GCM grid cell** and **RCM grid**

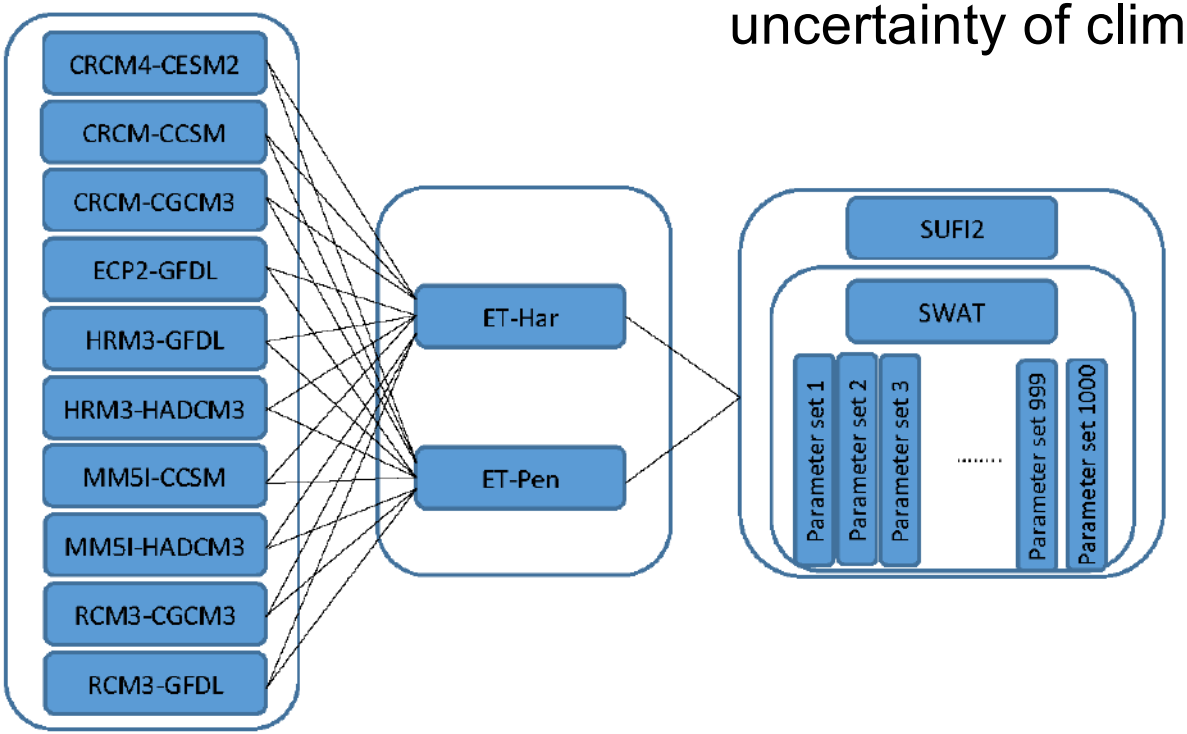


RCM Projections for the 2050s vs 1971-2000





How regionalization and parameterization of a hydrologic model affect the cascade of uncertainty of climate-impact projections



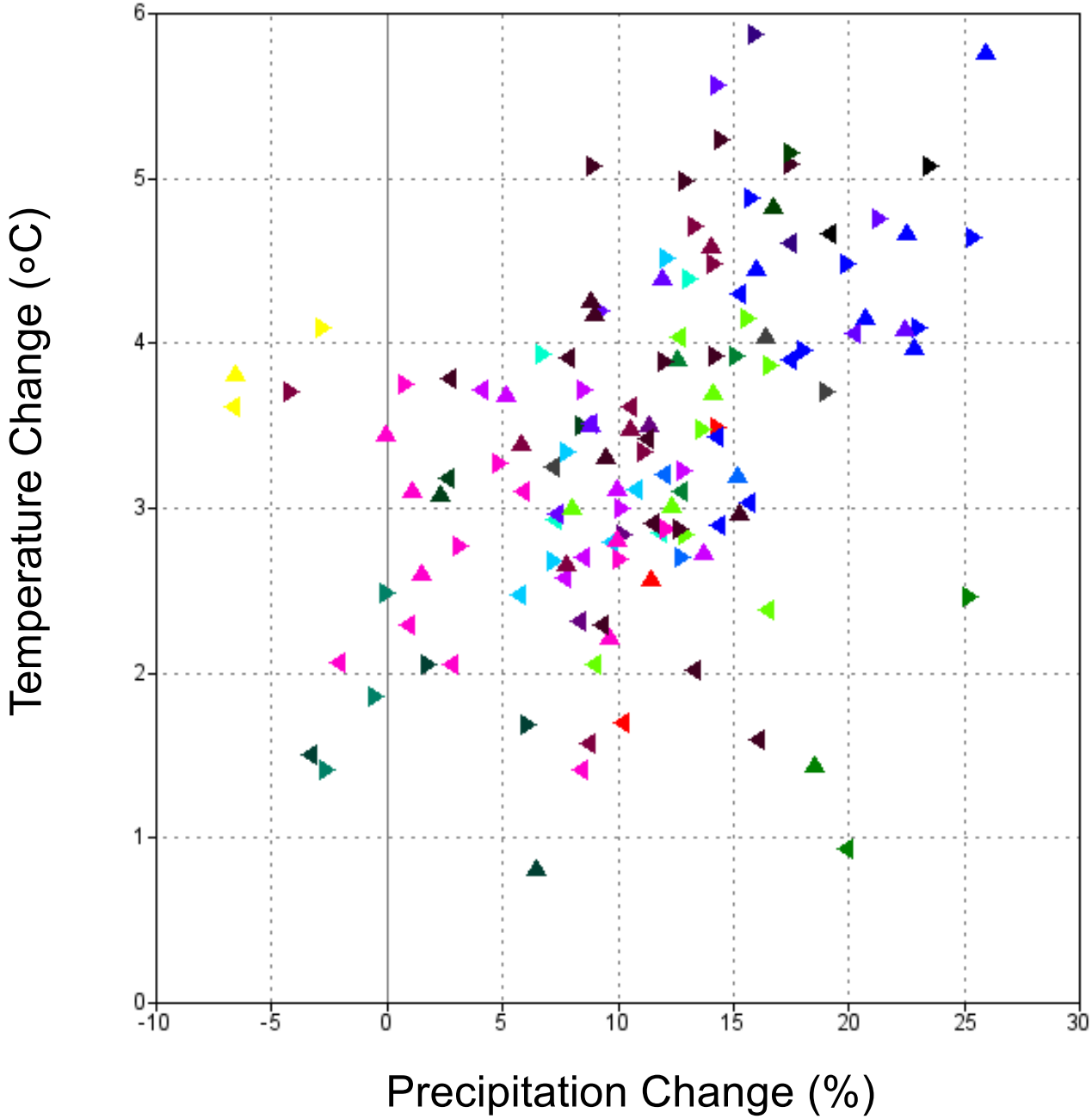
Ashraf Vaghefi, *et al*.
In Review
Climate Dynamics

The cascade of uncertainty

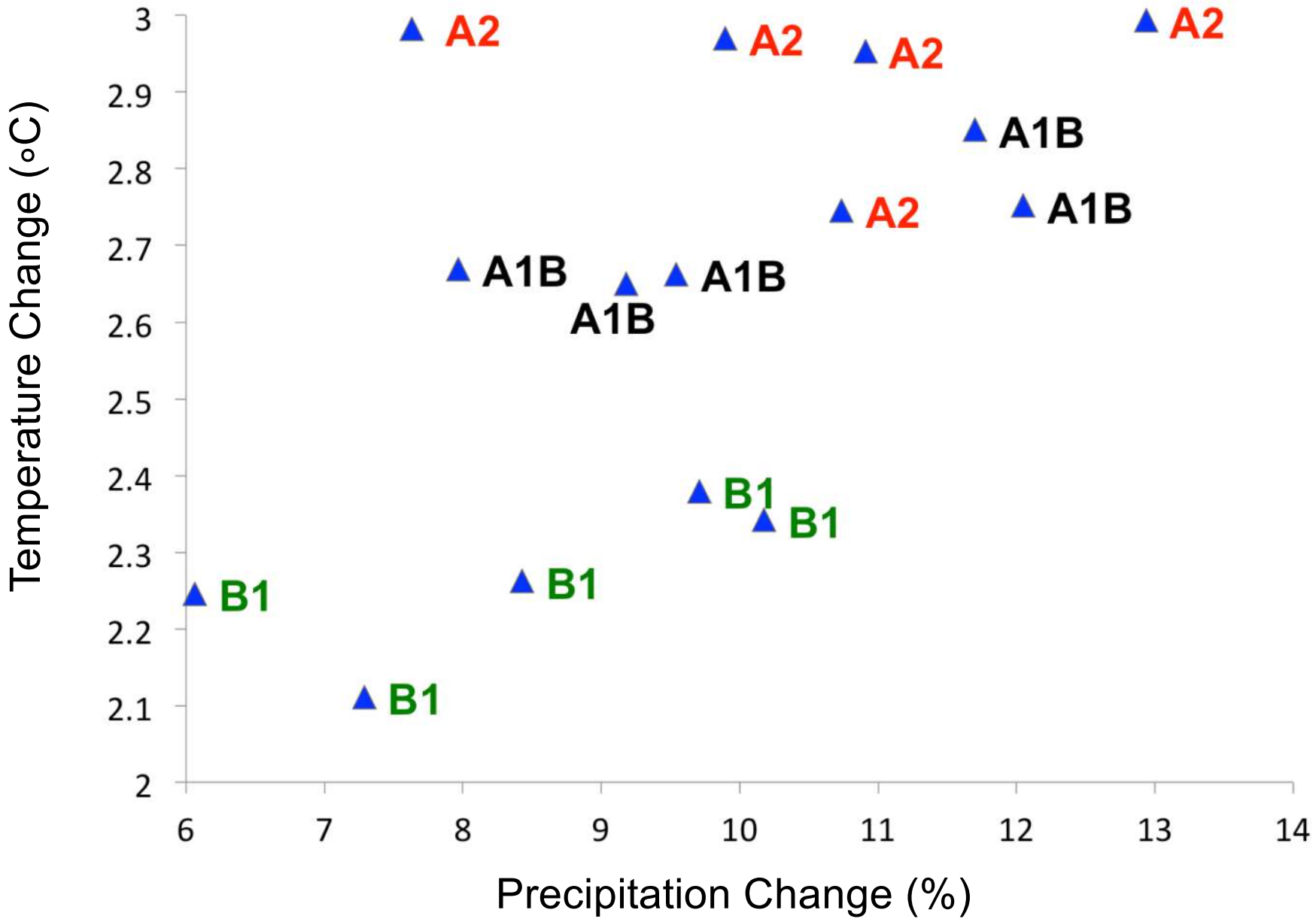
(Wilby and Dessai, 2010)

The envelope of uncertainty

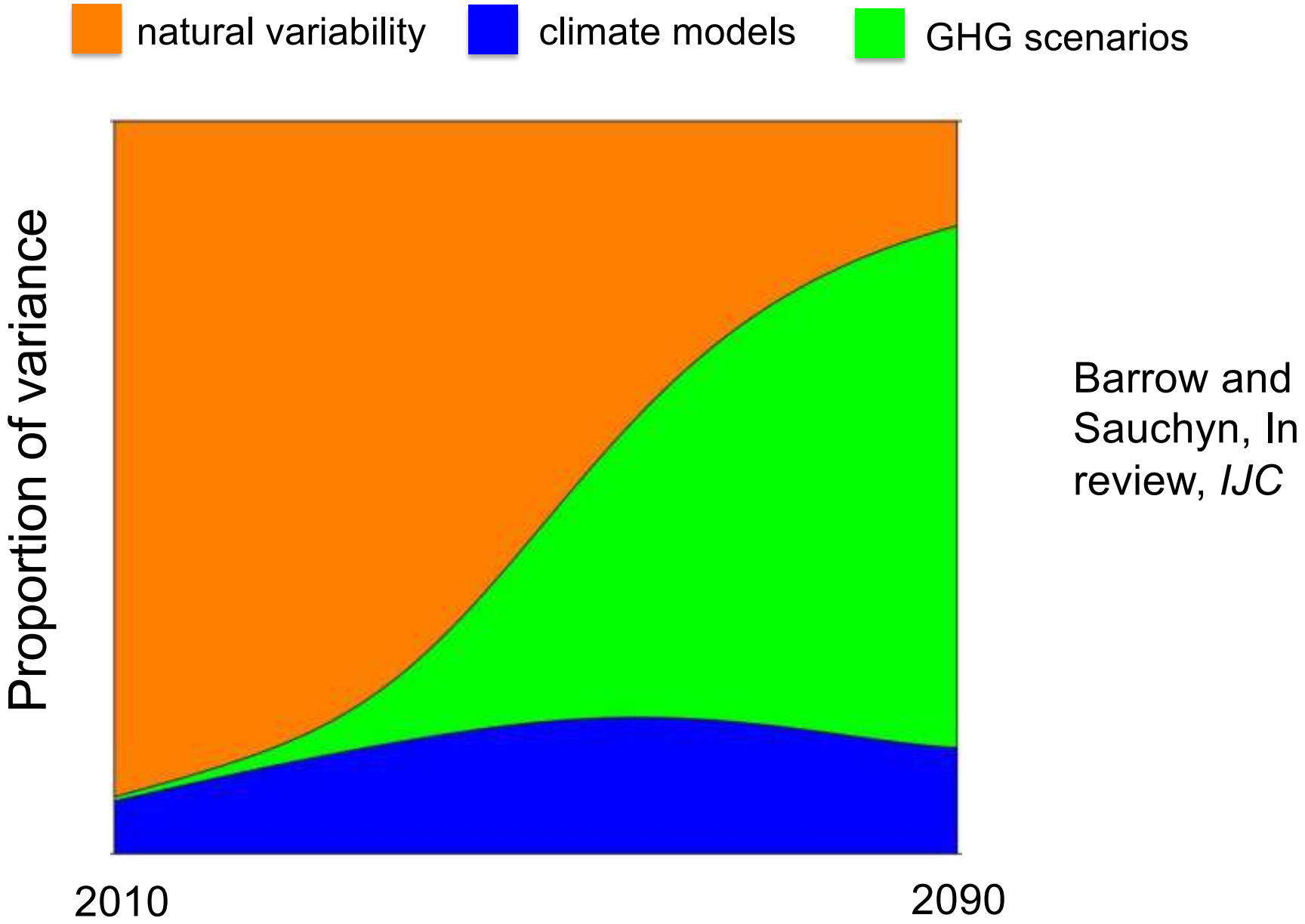
Projected climate changes, western Canadian winter
1961-90 to 2040-69



Projected Climate Changes, CGCM3, from 1961-90 to 2040-69

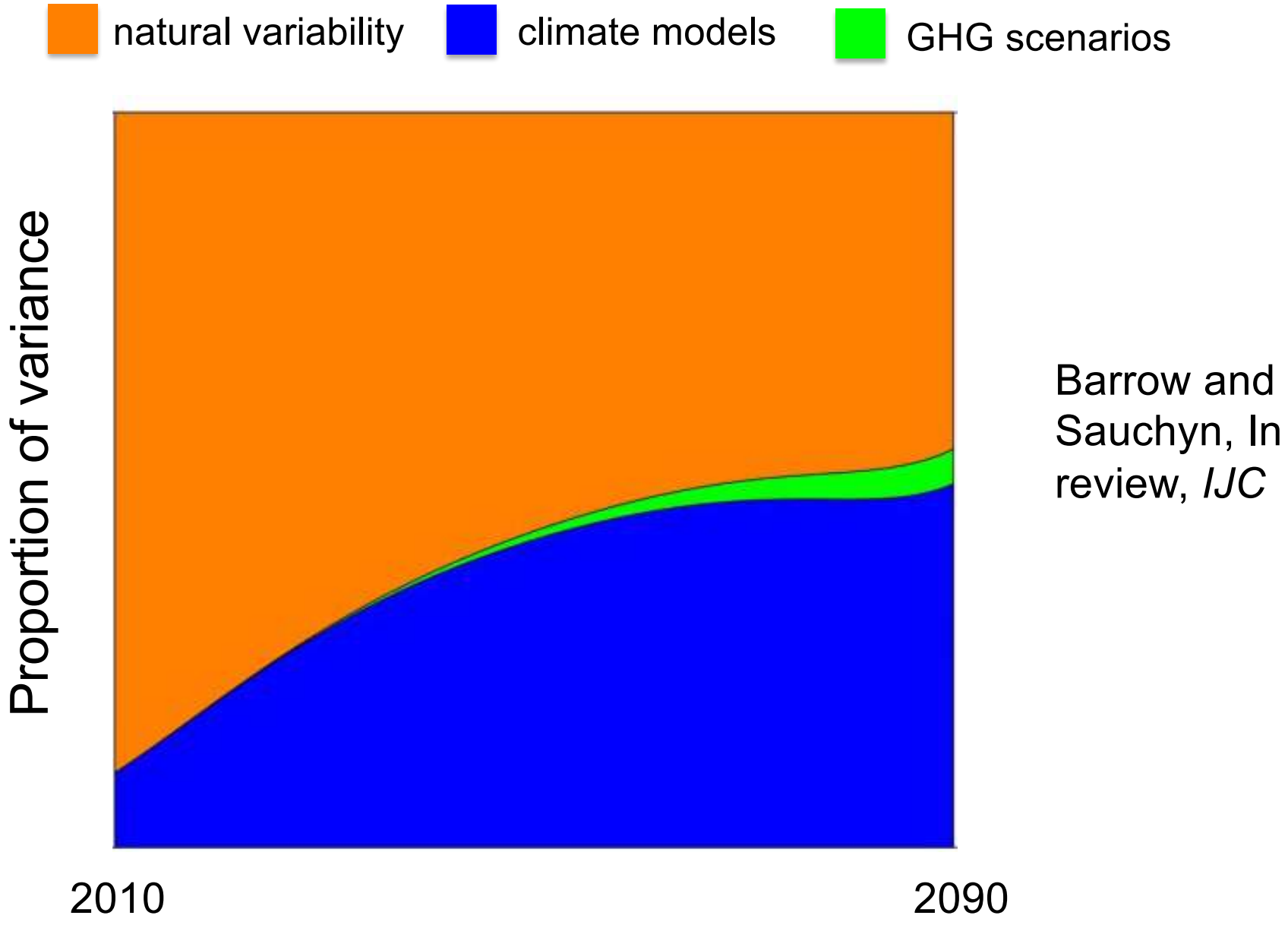


Sources of Uncertainty - Future Temperature



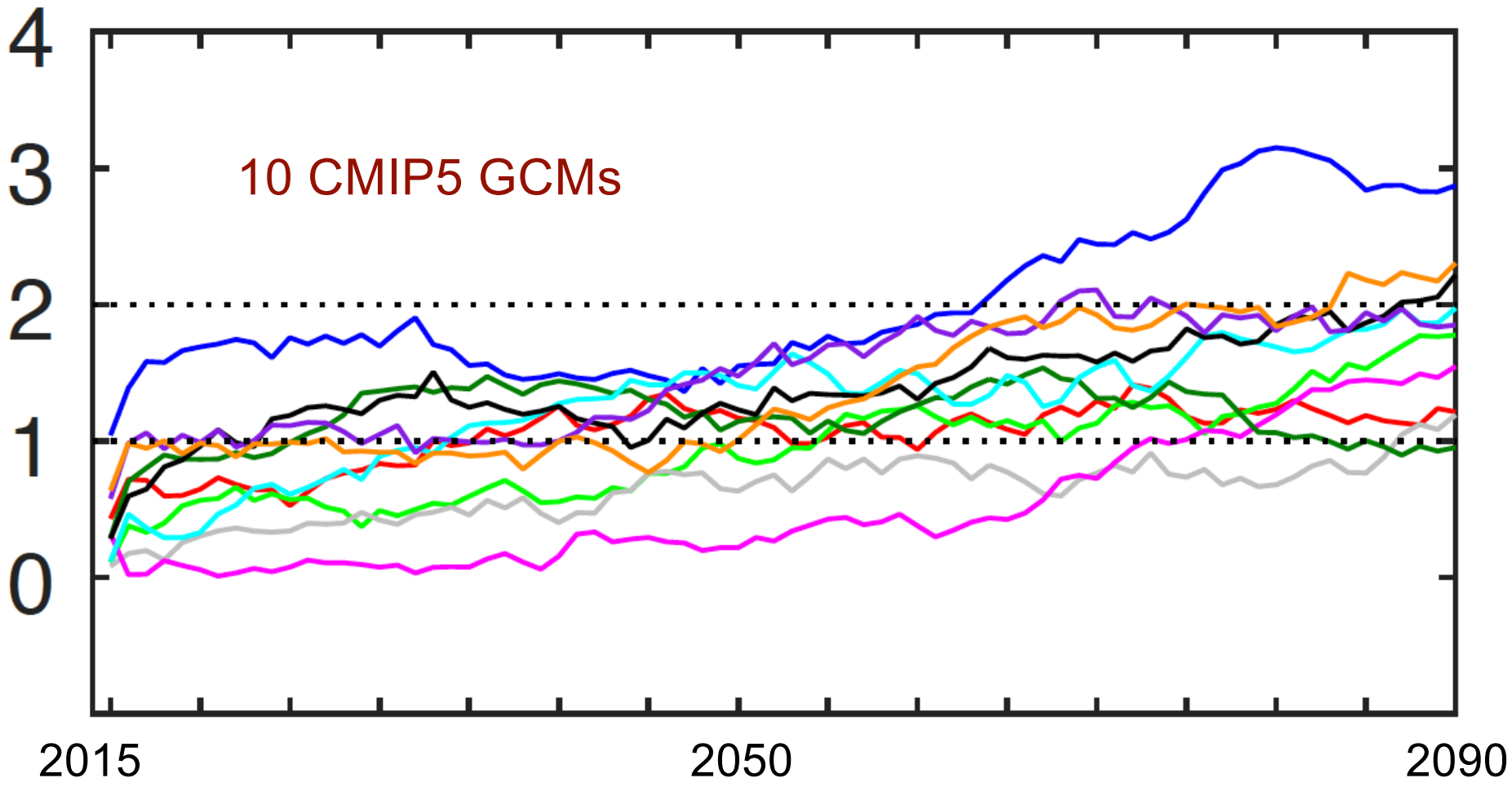
Barrow and Sauchyn, In review, *IJC*

Sources of Uncertainty - Future Precipitation



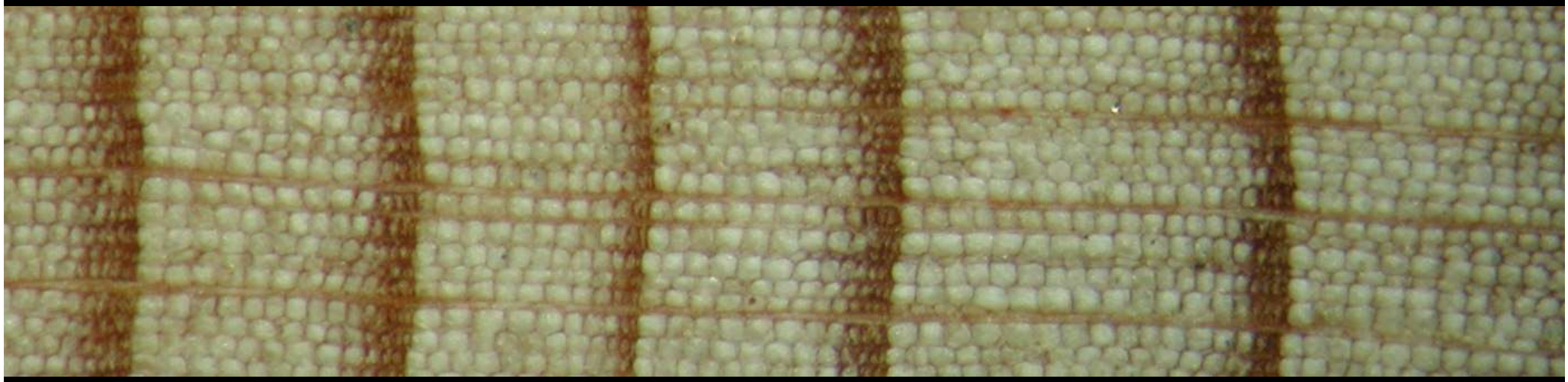
Barrow and Sauchyn, In review, *IJC*

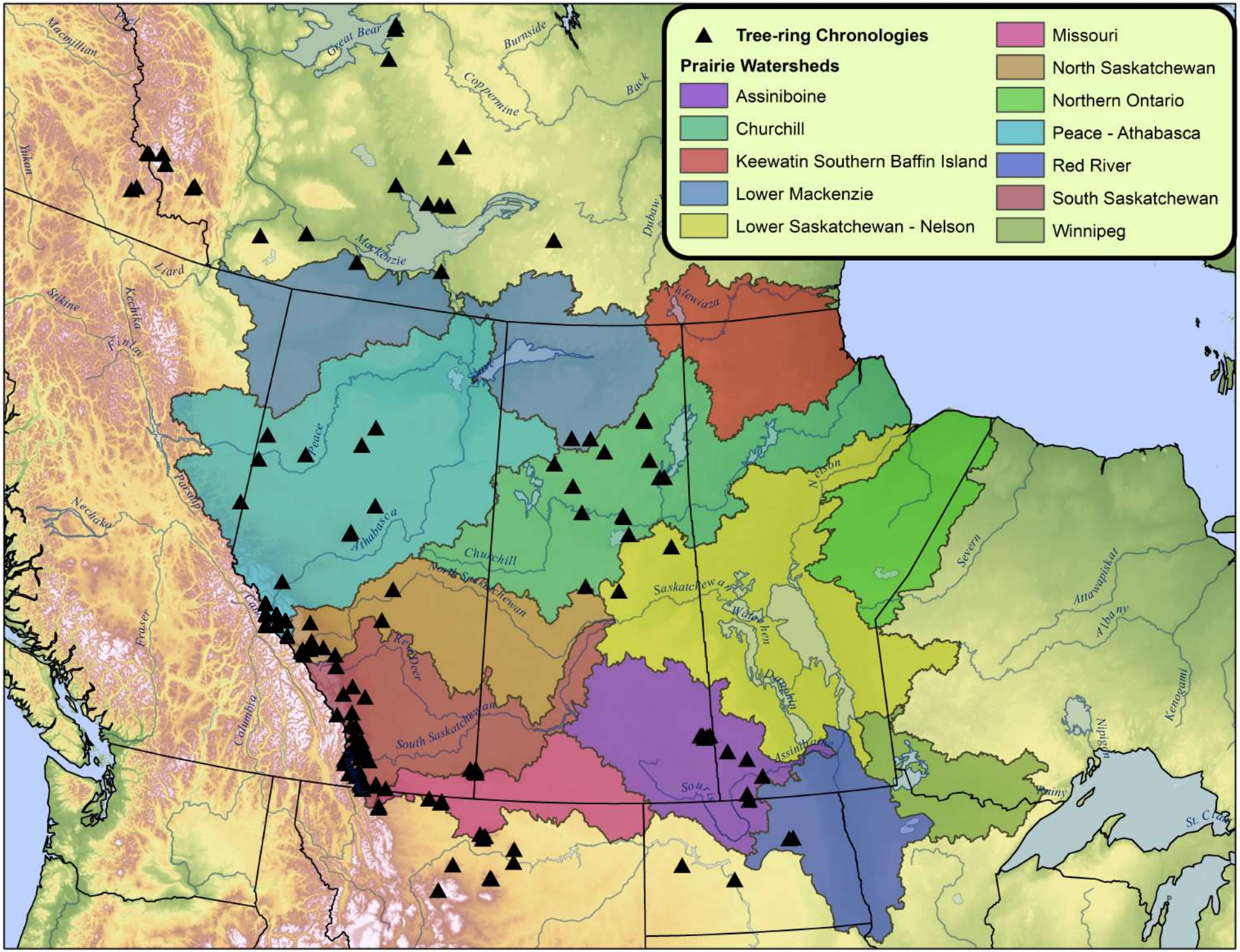
Signal to Noise Ratio, Winter Precipitation, Western Canada

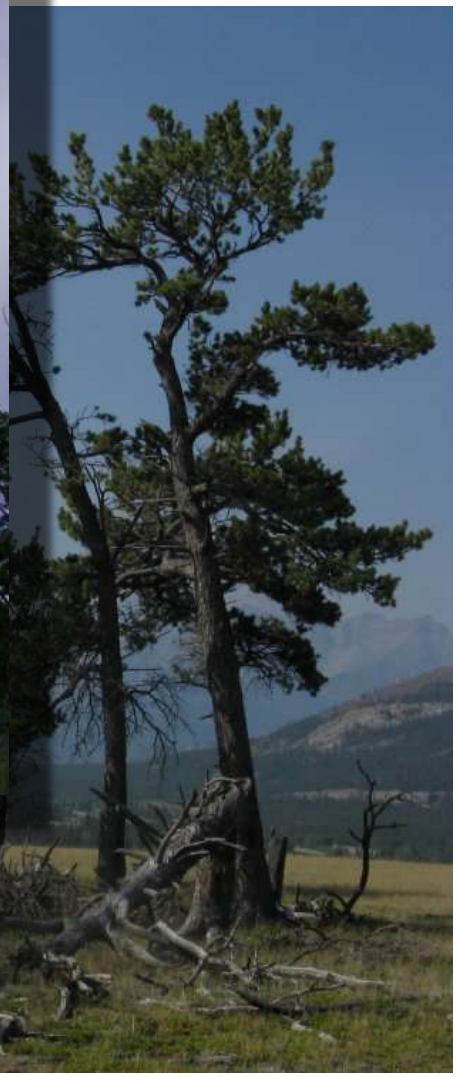


Barrow and Sauchyn, In review, *IJC*

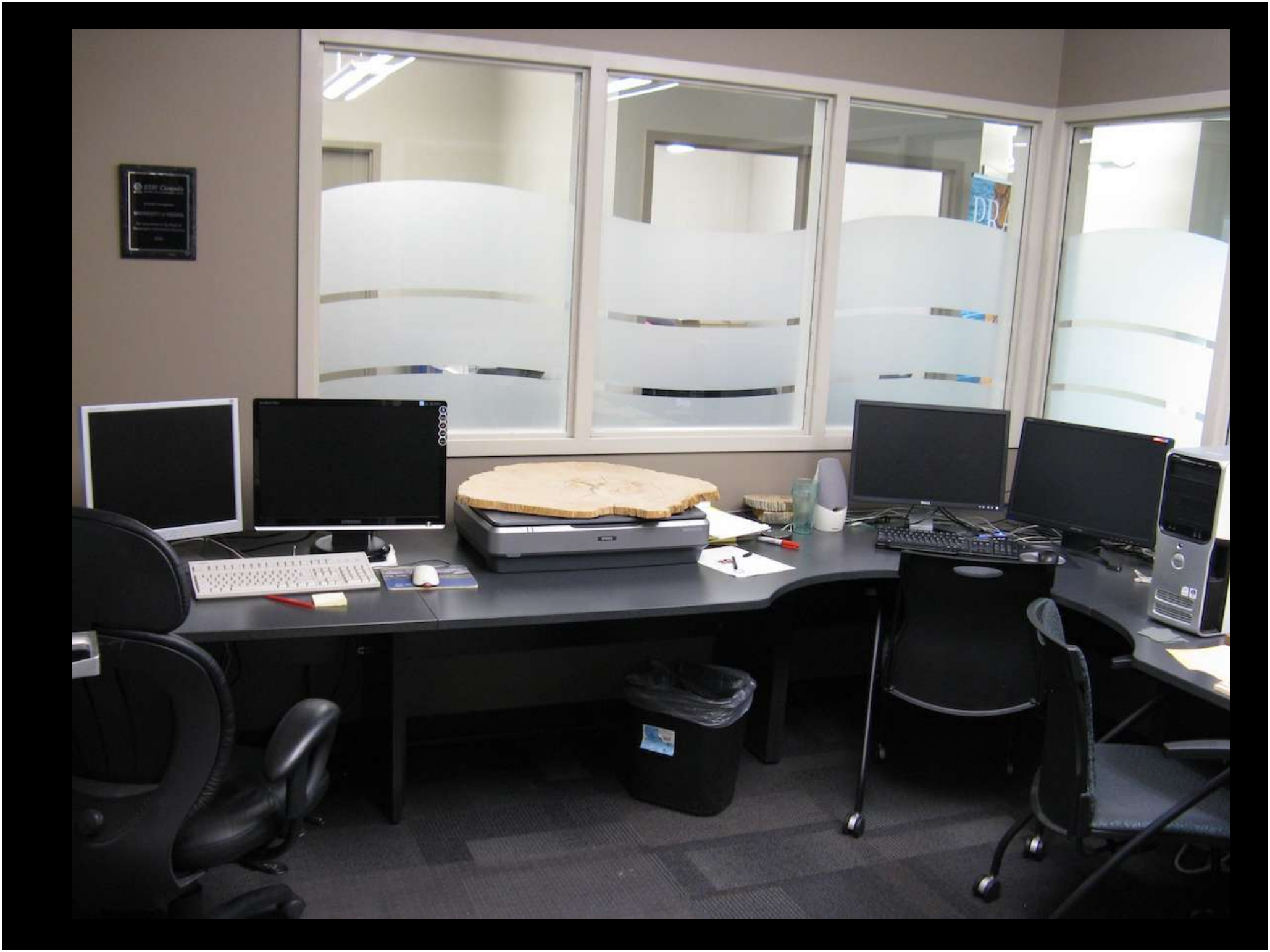

UNITED
DEWALT
DW735
UNITED



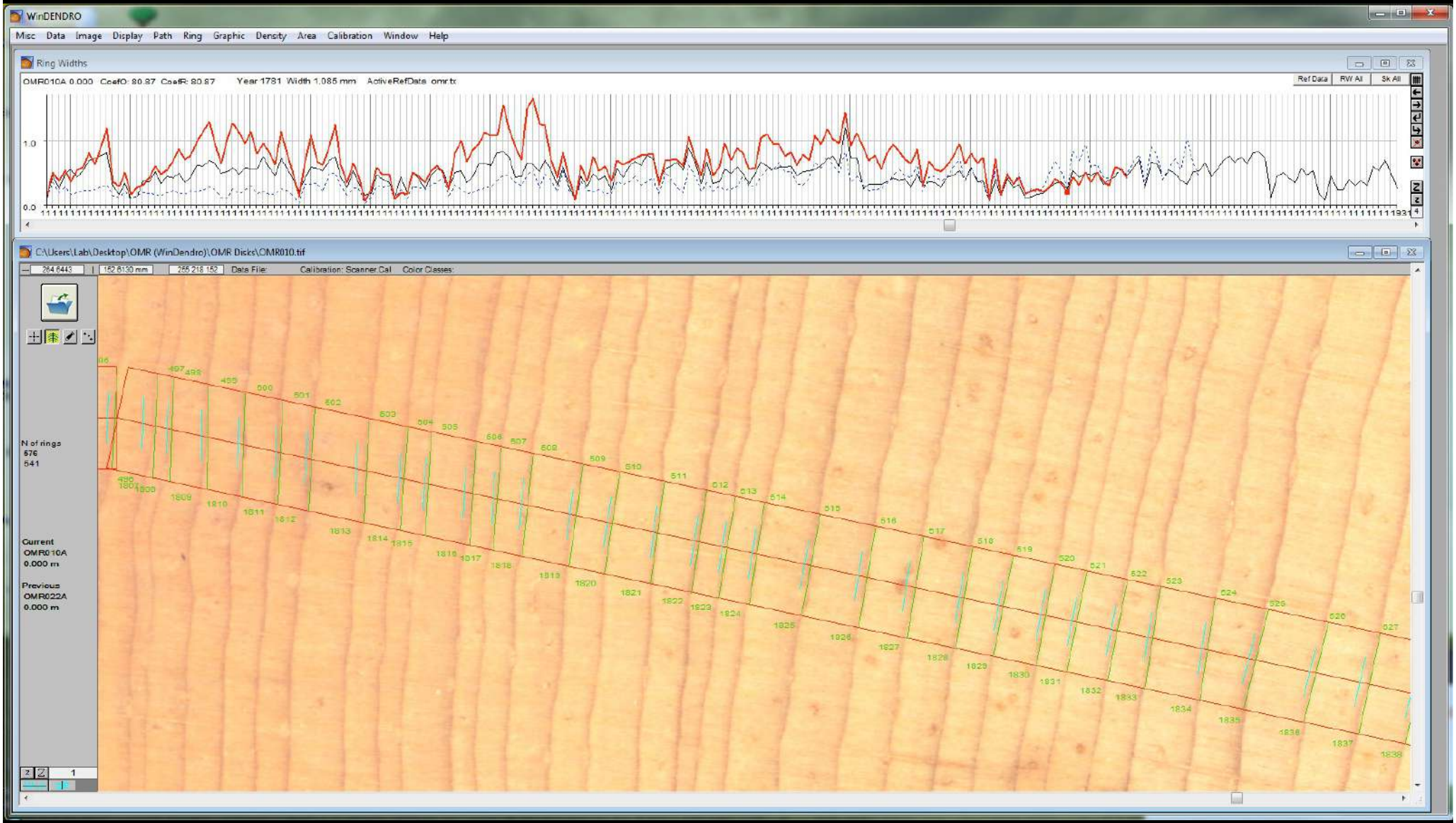

Tree-ring Chronologies
Prairie Watersheds
Assiniboine
Churchill
Keewatin Southern Baffin Island
Lower Mackenzie
Lower Saskatchewan - Nelson
Missouri
North Saskatchewan
Northern Ontario
Peace - Athabasca
Red River
South Saskatchewan
Winnipeg
Great Bear
Burnside
Coppermine
Back
Macmillan
Peel
Yukon
Liard
Mackenzie
Dubawnt
Thlewiaza
Kechika
Finlay
Peace
Parsnip
Athabasca
Churchill
Nelson
Severn
Attawapiskat
Albany
Kenogami
Nechako
Fraser
Columbia
Red Deer
South Saskatchewan
Assiniboine
Winnipeg
St. Clair

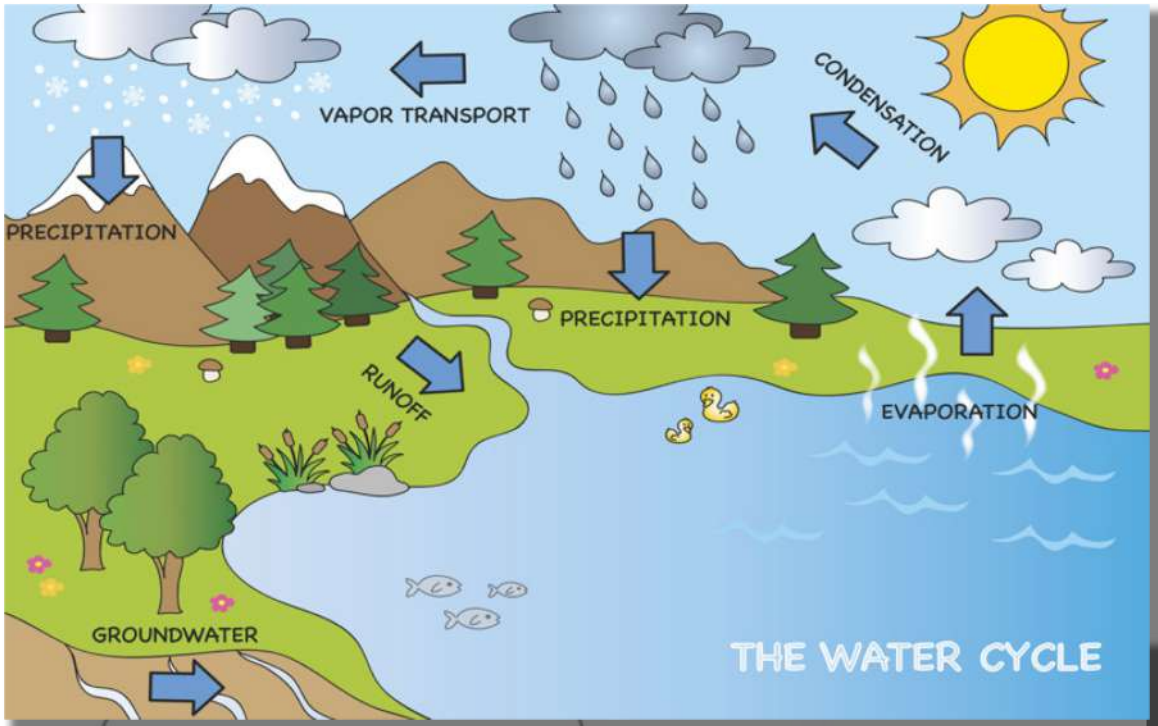


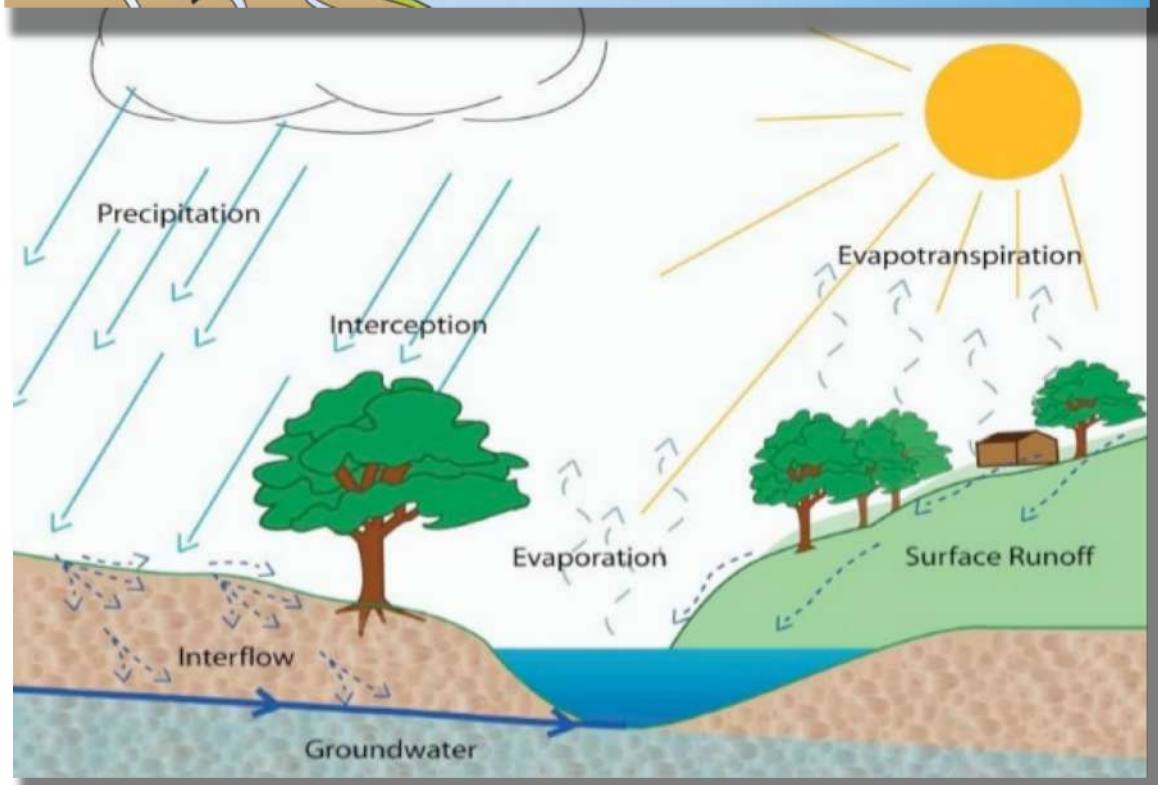

WALTER BARN
30F3
WALTER BARN
20F3

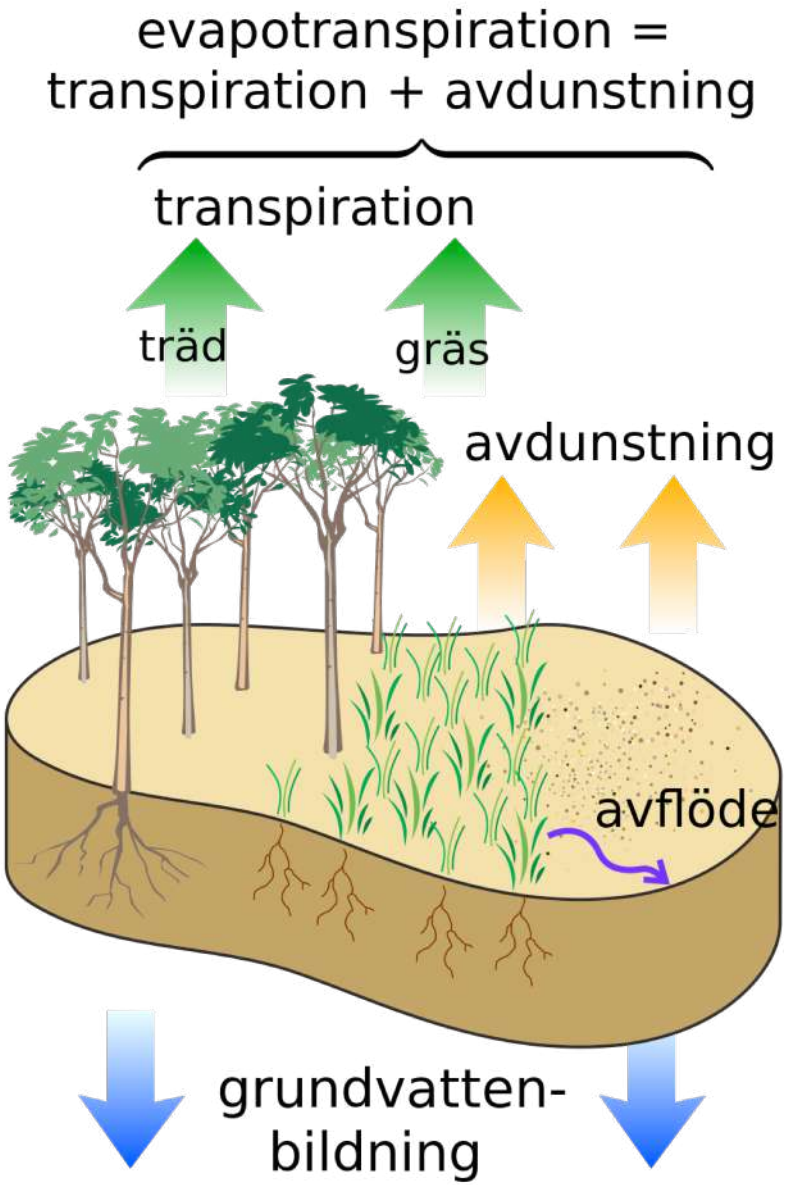


WinDendro: Semi-automated image analysis and measurement of tree rings

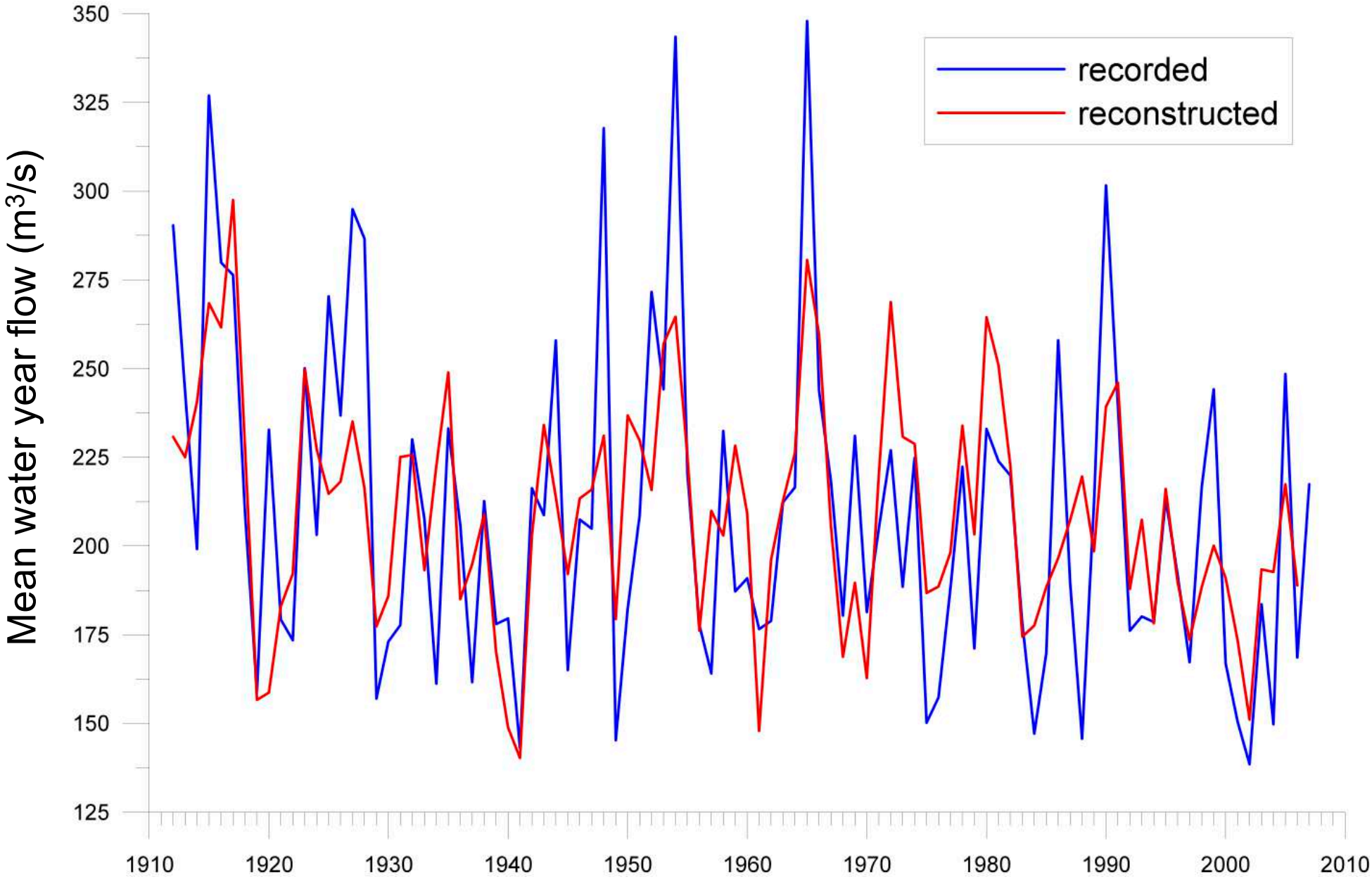



VAPOR TRANSPORT
CONDENSATION
PRECIPITATION
PRECIPITATION
RUNOFF
EVAPORATION
GROUNDWATER
THE WATER CYCLE

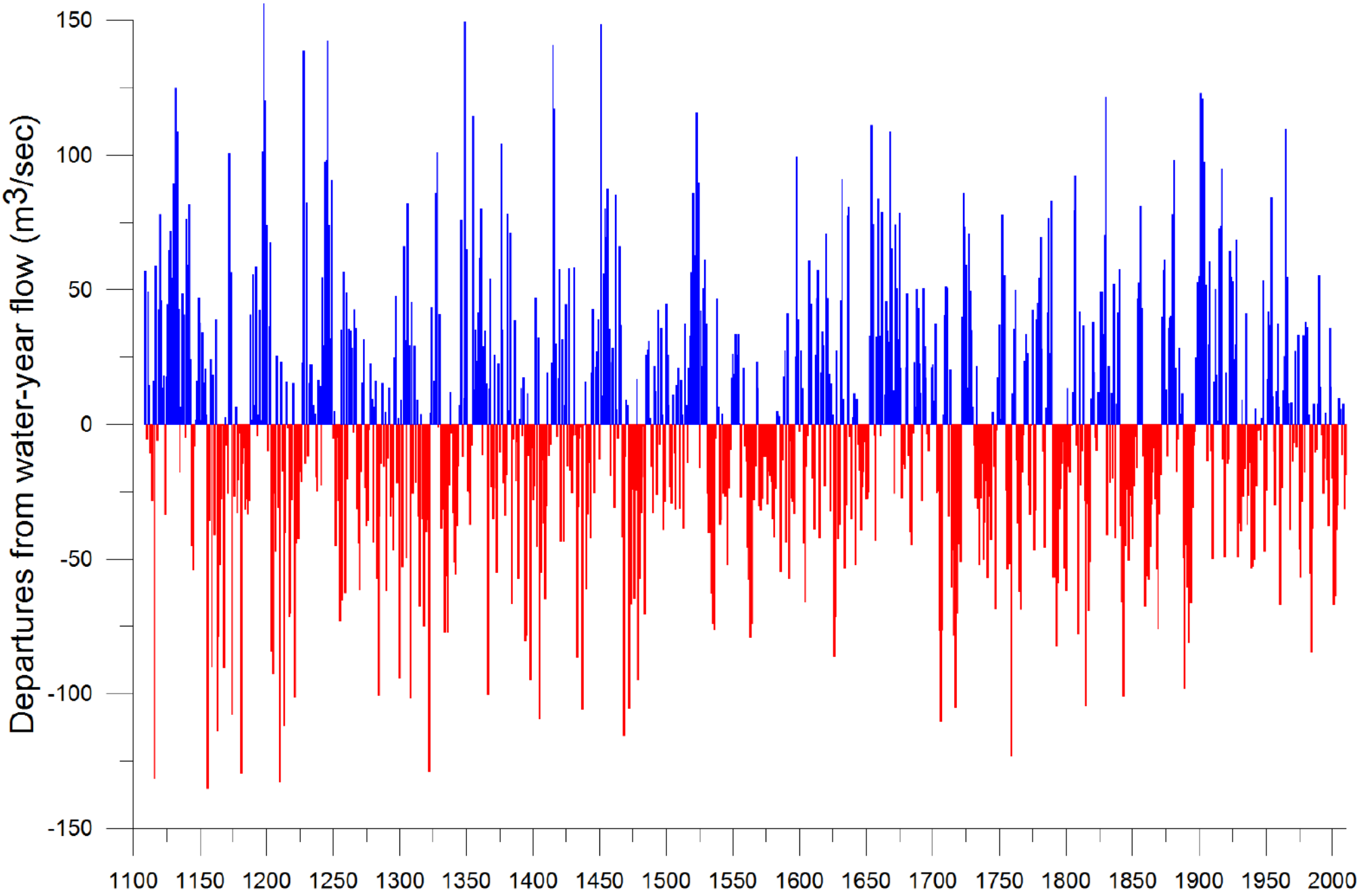

Precipitation
Evapotranspiration
Interception
Evaporation
Surface Runoff
Interflow
Groundwater


evapotranspiration =
transpiration + avdunstning
transpiration
träd
gräs
avdunstning
avflöde
grundvatten-
bildning

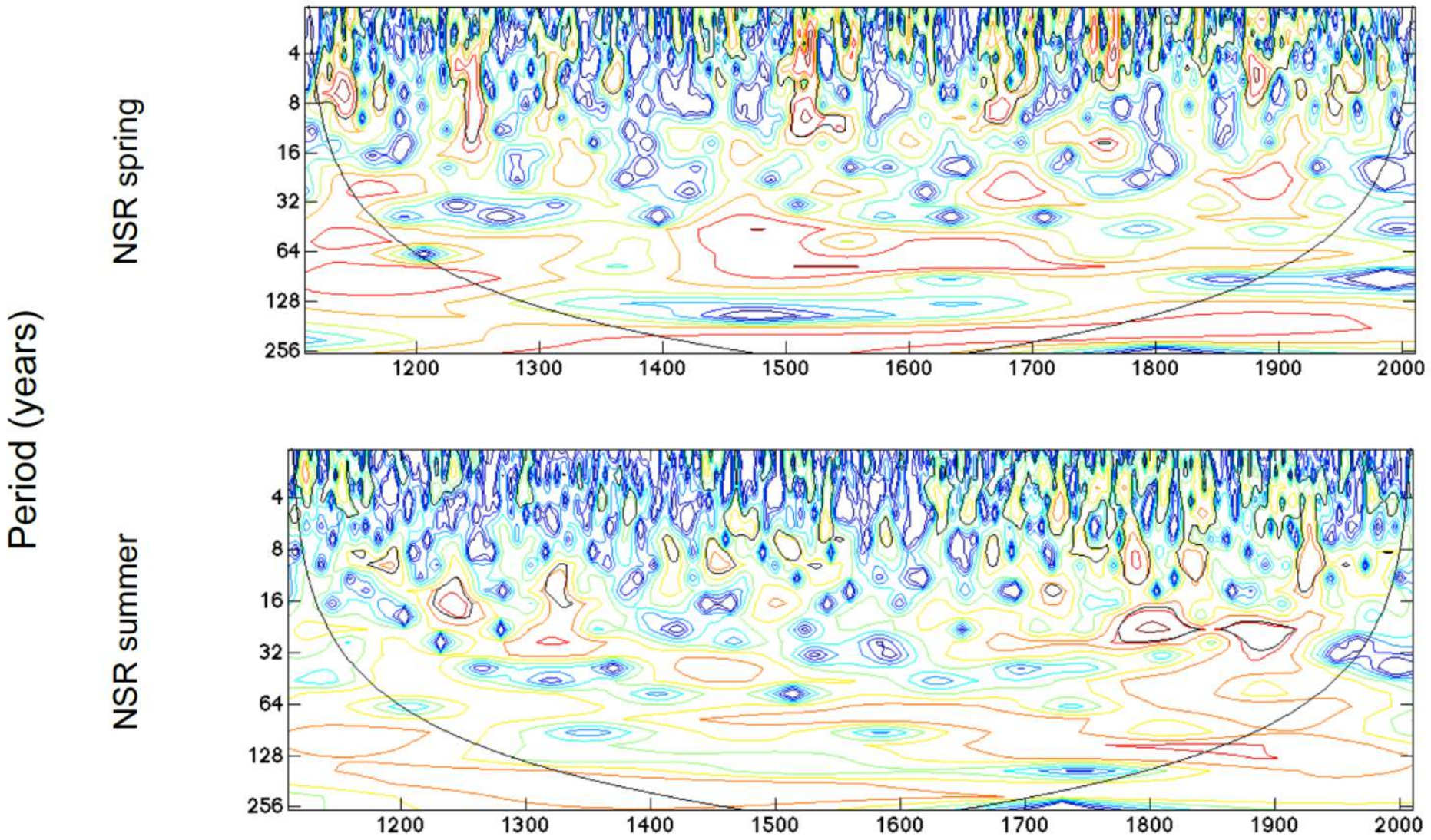
North Saskatchewan River at Edmonton, 1912-2010

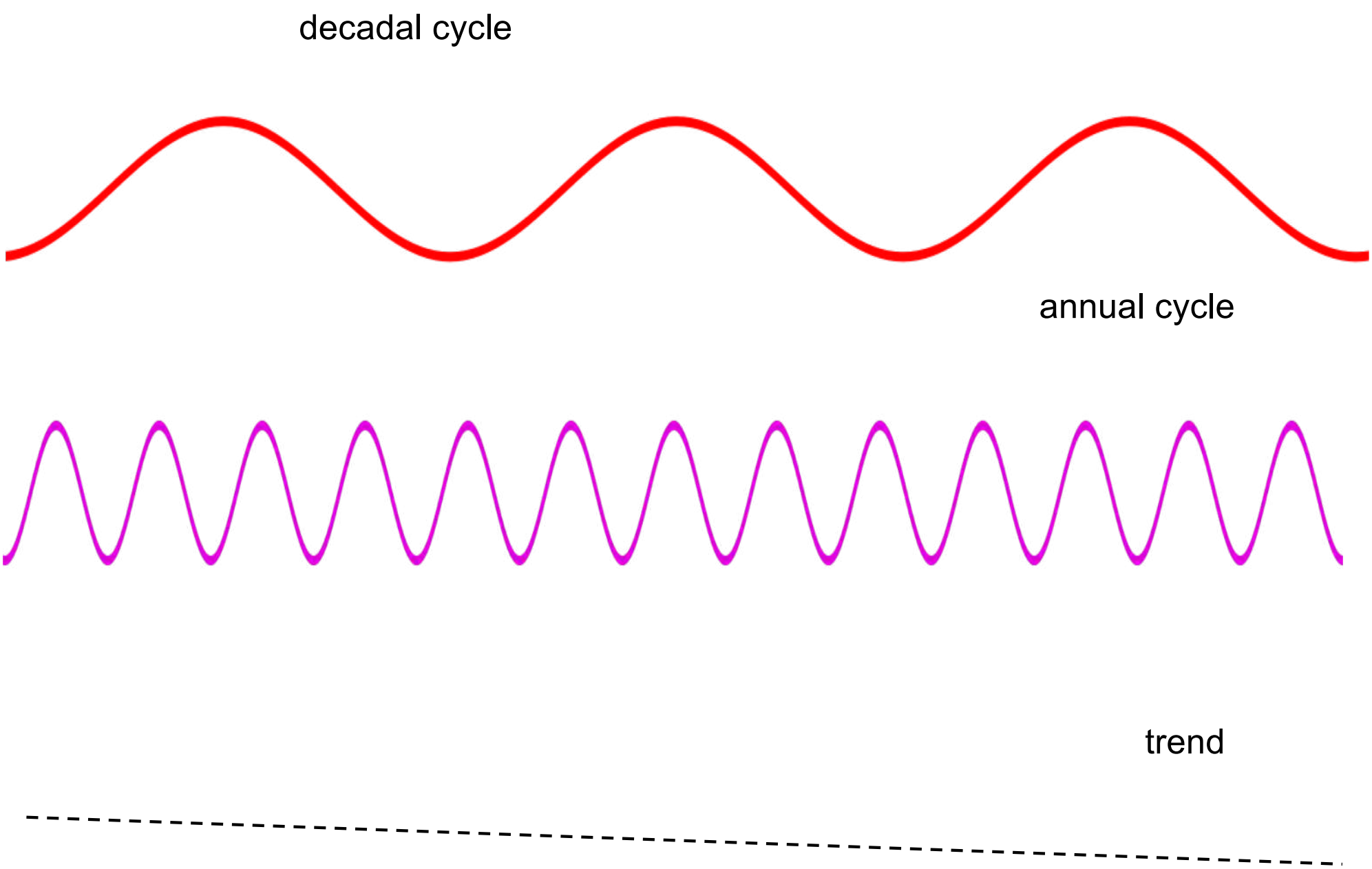


North Saskatchewan River at Edmonton, 1110-2010

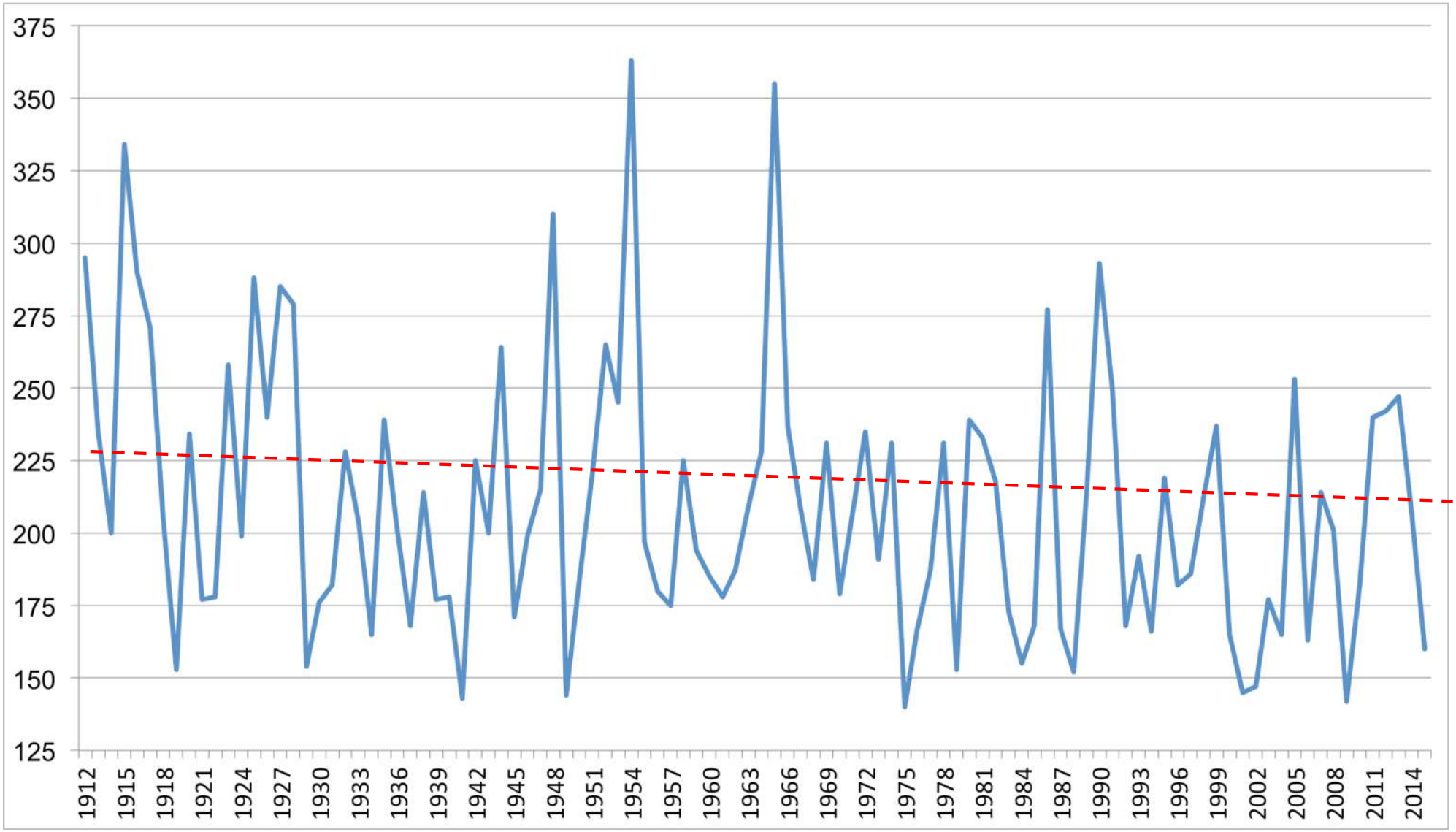


Wavelet plots of periodic variability in mean seasonal flow, North Saskatchewan River



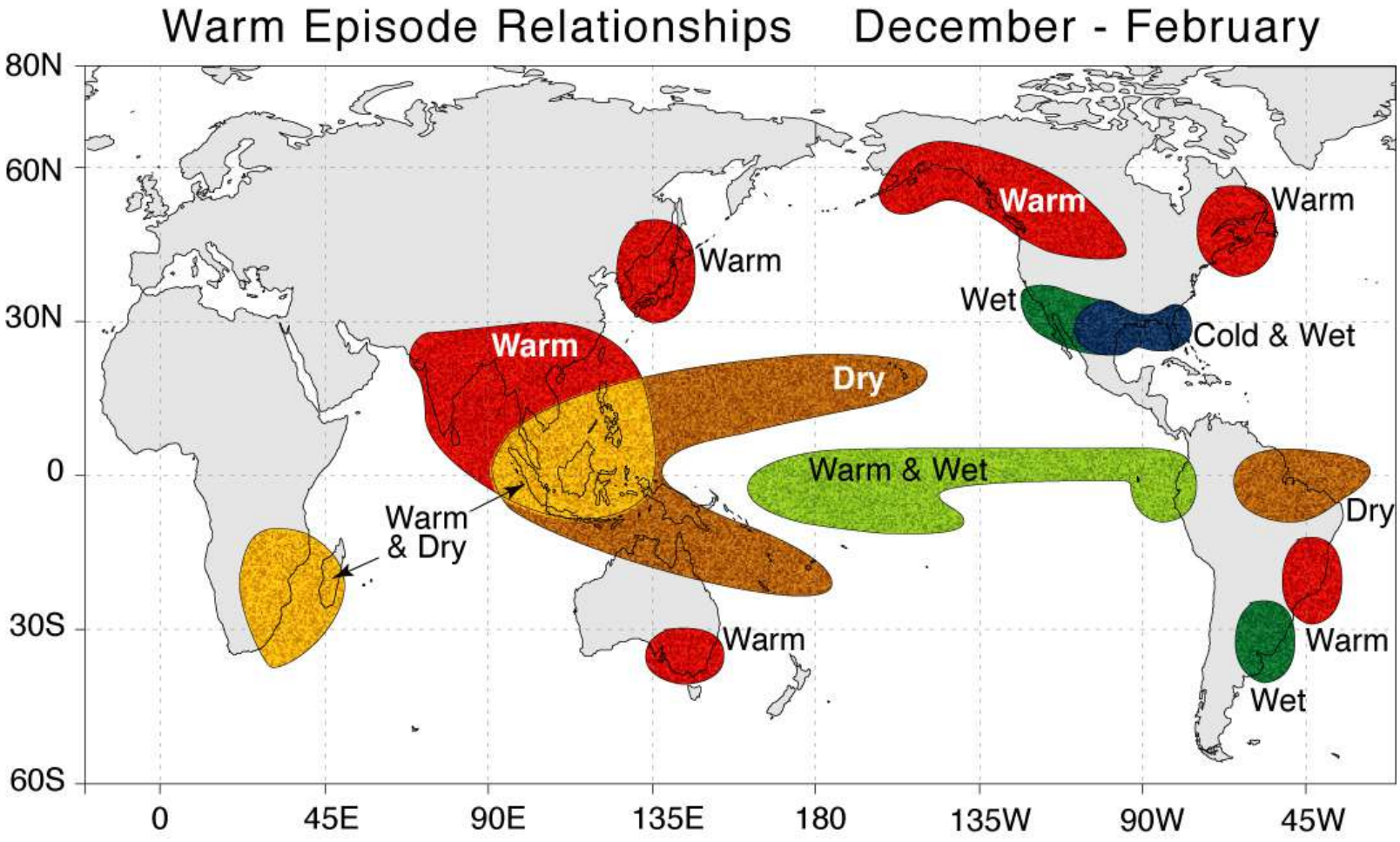

decadal cycle
annual cycle
trend

North Saskatchewan River at Edmonton
Mean Annual Year Flow (m^3/s), 1912-2015



El Niño remote impacts: Teleconnections

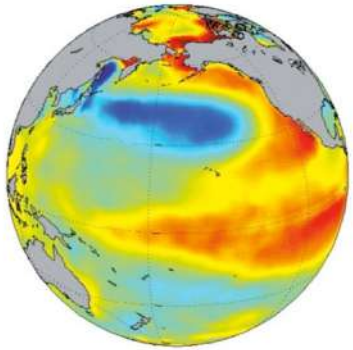
La Niña teleconnections have the opposite effect

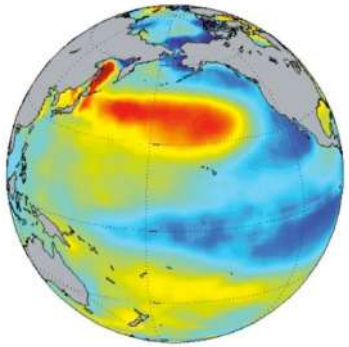


Neelin, 2011. *Climate Change and Climate Modeling*

PDO Index, 1912-2010

(Source: NOAA)





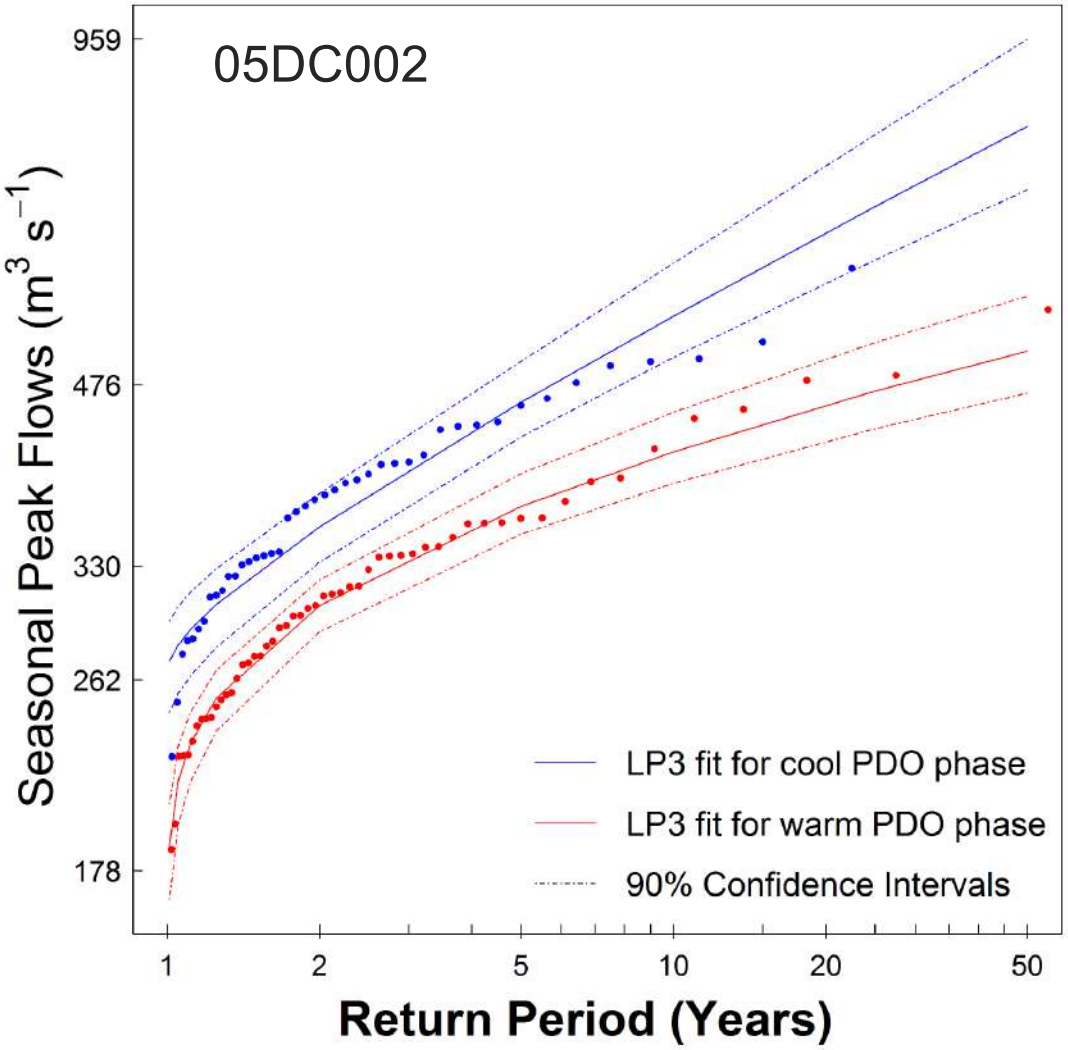
4
3
2
1
0
-1
-2
-3
-4

1912 1913 1915 1917 1918 1920 1922 1923 1925 1927 1928 1930 1932 1933 1935 1937 1938 1940 1942 1943 1945 1947 1948 1950 1952 1953 1955 1957 1958 1960 1962 1963 1965 1967 1968 1970 1972 1973 1975 1977 1978 1980 1982 1983 1985 1987 1988 1990 1992 1993 1995 1997 1998 2000 2002 2003 2005 2007 2008 2010

Flood Frequency Curves

North Saskatchewan River at Saunders

- PDO stratified Peak Flows
  - **Neg**.: 1912-25, 1947-76, 2009-13
  - **Pos**.: 1926-46, 1977-2008
- Log-Pearson III (LP3) Fit
- 90 % Confidence Intervals



Gurrapu et al., 2016, JAWRA

2011

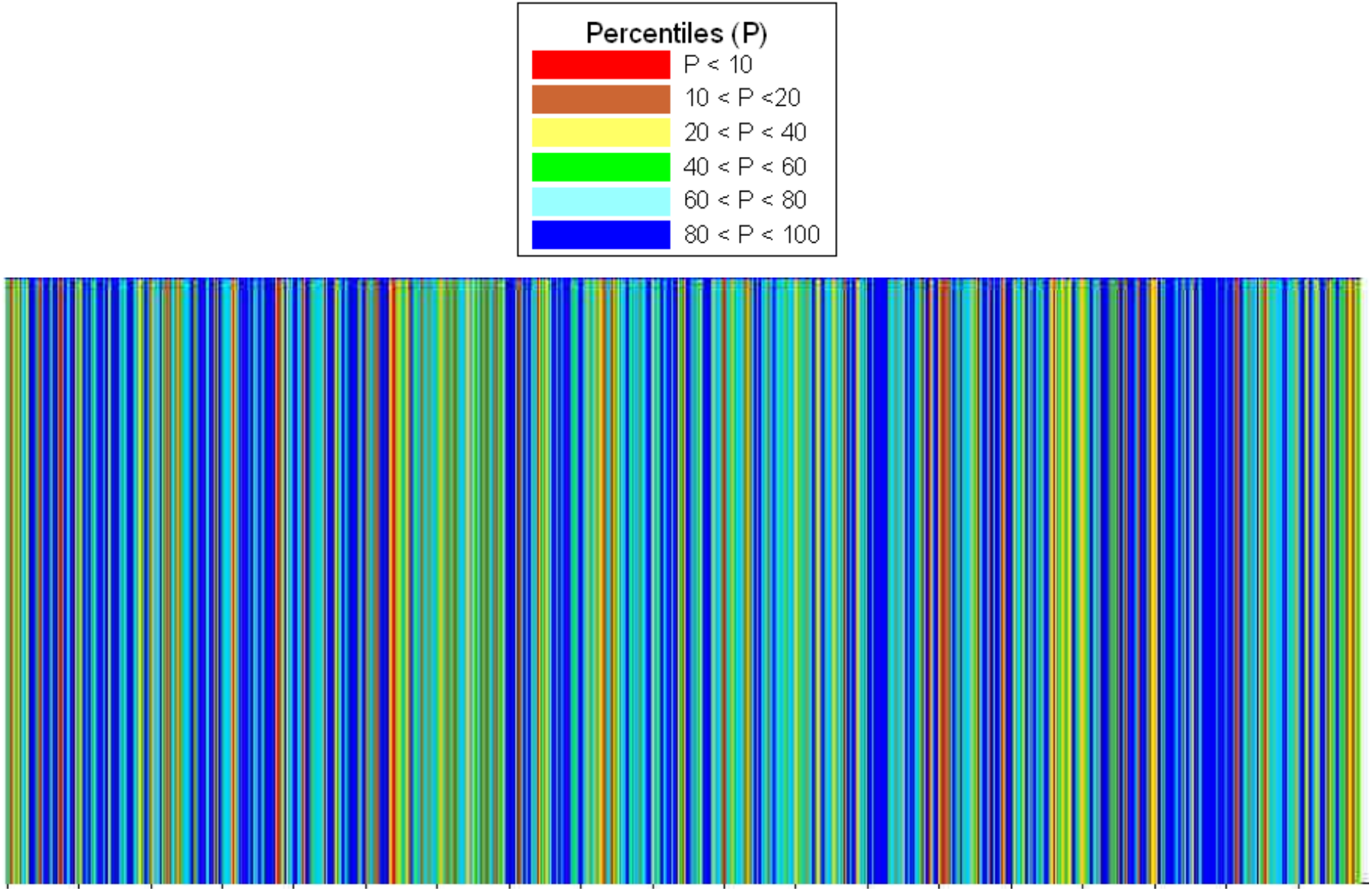
City of Calgary: Drought Management Plan

Address Information Gaps:

"In order to expand The City's understanding of historical drought conditions it is important to **reevaluate historical drought using tree ring analysis** historically conducted by the David Sauchyn (University of Saskatchewan [*sic*])"

SW Saskatchewan September 2015

North Saskatchewan River at Edmonton, 1063-2006

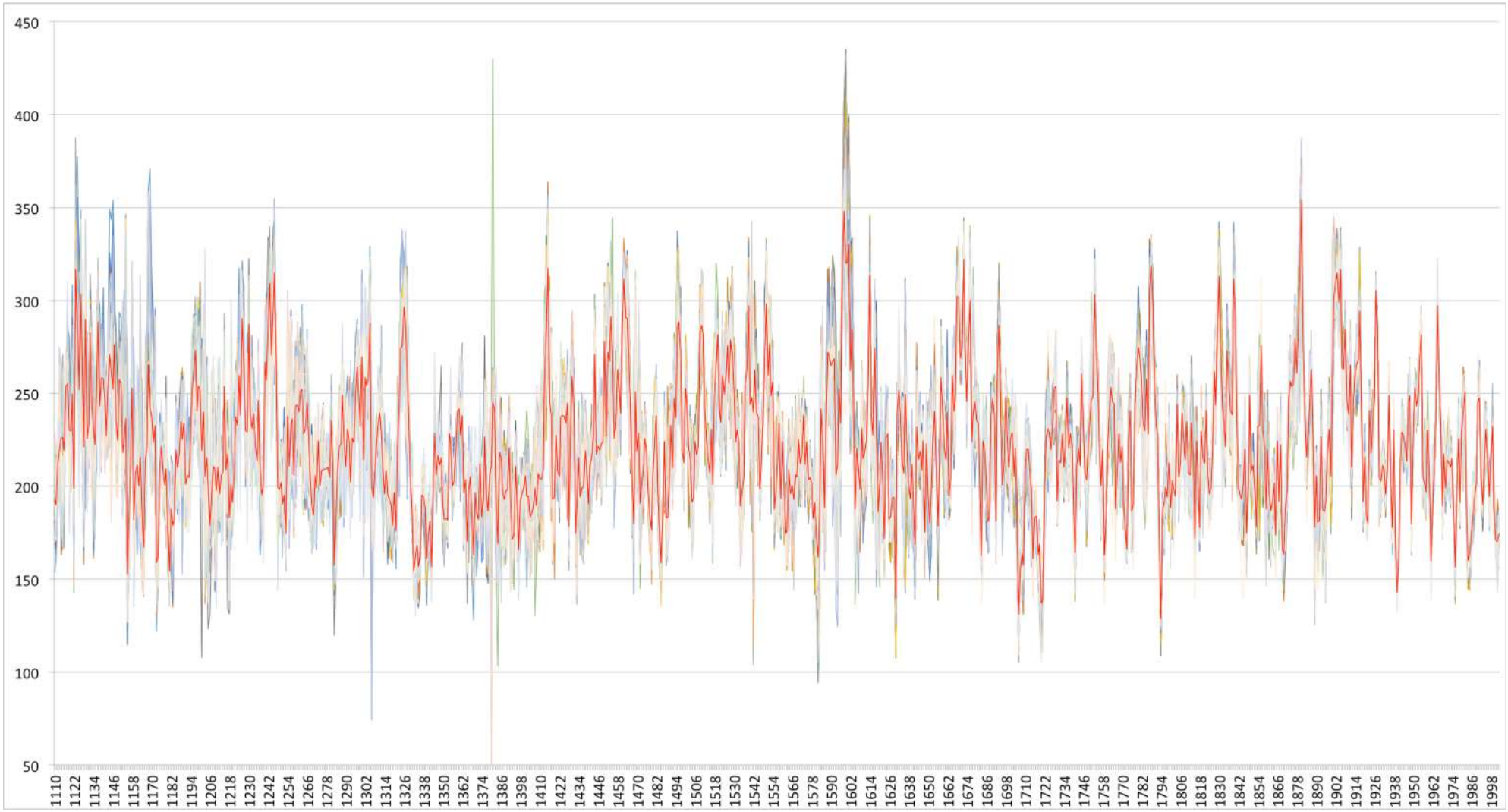


why do keep collecting more wood, don't you have enough?

- Farmer X

Flagstaff County Agricultural Symposium
Sedgewick, Alberta, 28 July 2012

Ensemble of 100 reconstructions of water-year flow (m^3/s) North Saskatchewan River, 1110-2010



ensemble mean

Sauchyn and Ilich, 2017, *WRR*

EPCOR Utilities Ltd provides water supply and wastewater treatment to 85 communities in western Canada

March 2007:

Traditional planning would **consider flow characteristics of the raw water streams as "knowns"** in the system. [*… that is, a stationary climate and water regime*]

EPCOR

Canadian Association on Water Quality Conference, 21 February 2012, Burlington ON

Managing the Impact of Climate Change on Municipal Source Water Supply

L. Gyurek, S. Craik, & S. Neufeld, EPCOR Water Services Inc.

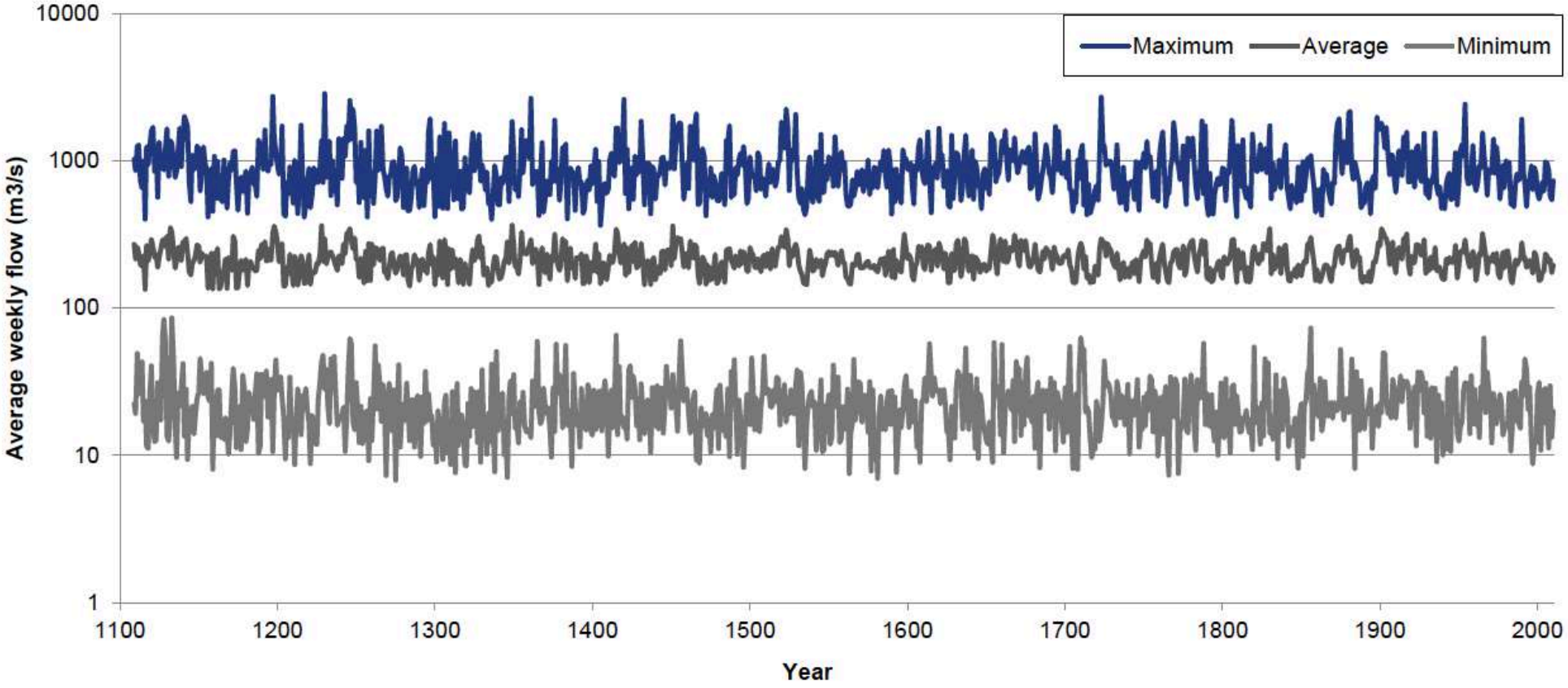
… a better understanding of natural hydroclimatic variability in surface waters, water utilities including EPCOR are **revisiting this assumption of a static water supply**. Specifically EPCOR supported collaborative research with the **Prairie Adaptation Research Collaborative** … **a thousand year record of hydroclimatic variability** … This work will allow EPCOR to better assess future risks to water supply and quality and develop risk mitigation strategies.

December 2014: Source Water Protection Plan

To address potential impacts of climate change on water supply, **EPCOR partnered with Prairie Adaptation Research Collaborative** (PARC) …

Understanding that water resources are not stationary, water management must be adjusted to a hydrological cycle which is increasingly sensitive to the timing and frequency of rainfall events. PARC is continuing to work with EPCOR to refine predictions and probabilities of water flow on a monthly basis in order to inform planning.

How low can it go?



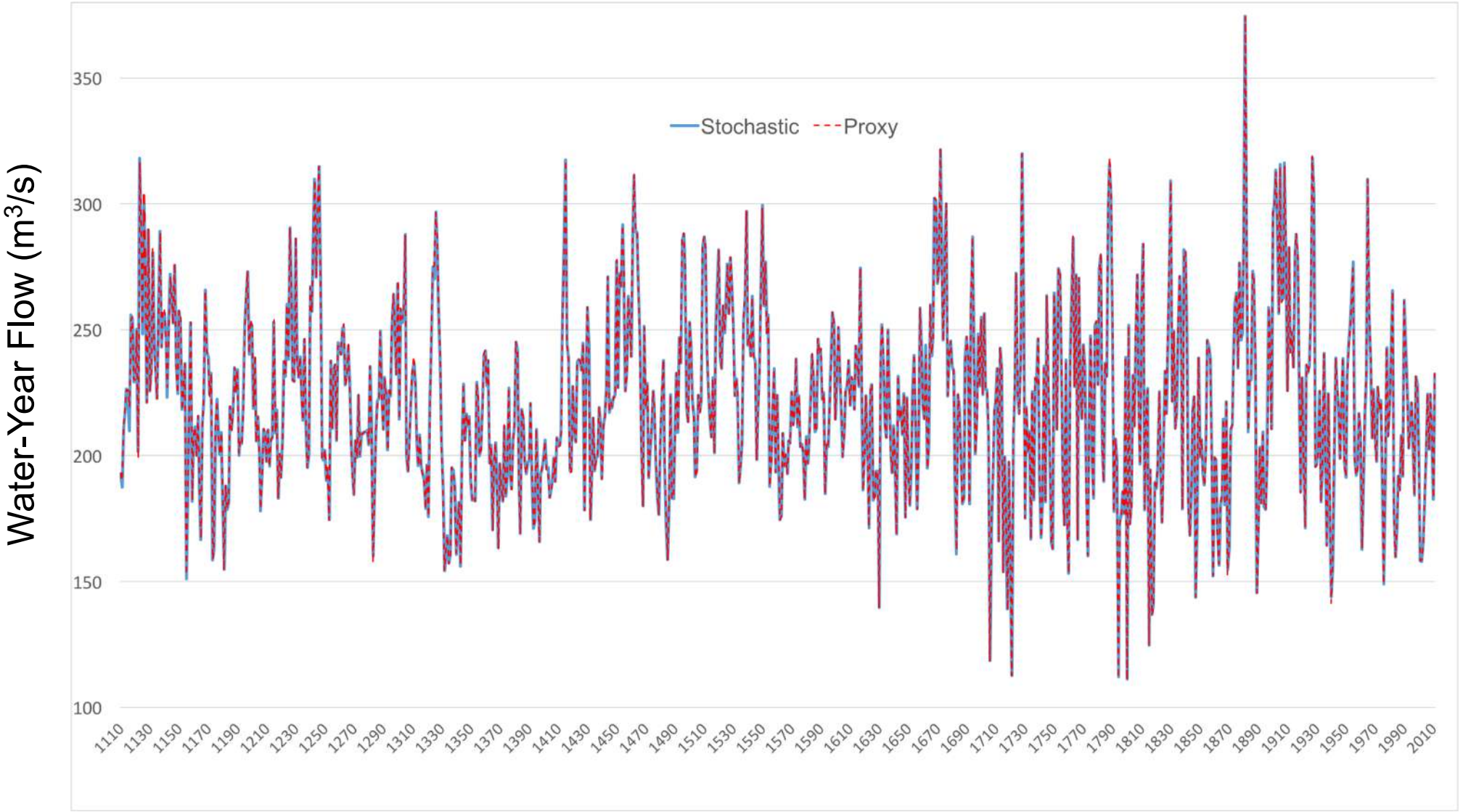
Very low- 10 m3/s where the river is likely series of disconnected pools

EPCOR

Neufeld (2016)

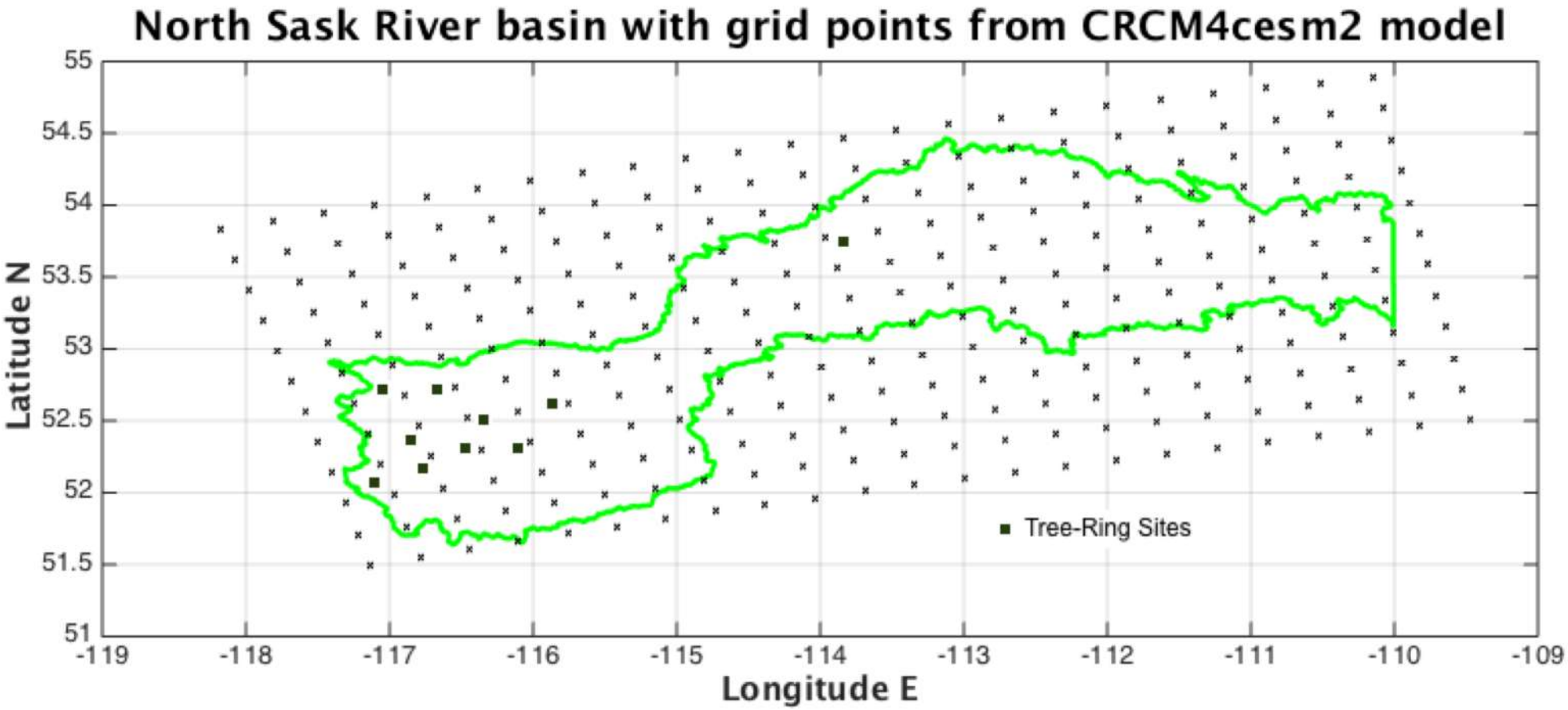
900 years of weekly flows, North Saskatchewan River

Sauchyn and Ilich, 2017, *WRR*



EPCOR ALBERTA INNOVATES THE CITY OF CALGARY

Natural and Externally Forced Hydroclimatic Variability in the North Saskatchewan River Basin



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