Water Availability in the South Saskatchewan River Basin under Climate Change

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Hydrology and the Canadian Prairies

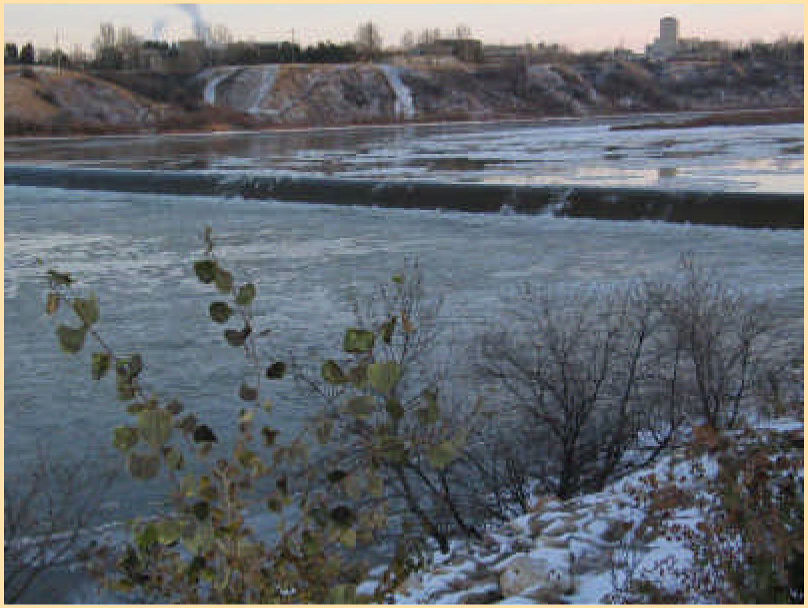
Some of the largest potential changes in surface water quantity under the currently predicted climate scenarios are in the Canadian prairies.

Adapting to these changes requires sophisticated understanding of the hydrological cycle within the prairie eco-zone in tandem with understanding the influence that human intervention on the landscape has made to the hydrological regime.

Objective

- To predict the future water availability in the South Saskatchewan River Basin (SSRB) under the potential impact of climate change using hydrologic models calibrated to SSRB and forced by downscaled climate scenarios projected by some selected general circulation models (GCM).
- To prove the utility of a physical modeling study linked and integrated to water policy via a socio-economic study

The scenarios will allow others to examine surface water resources management strategies on the prairies in an integrated watershed management framework under varying climate scenarios.



GCM Analysis

<u>GCM Data</u>

CCRS-NIES
CGCM1
CGCM2
CSIROMK2b
ECHAM4
GFDL-R15
GFDL-R30
HadCM2
HadCM3
NCAR-DOE
NCAR-PCM

<u>Observed Data</u>

IDW – Prairie & Northern Region
CRU – Climatic Research Unit
WATMPPR – U of Waterloo

1961-1990 current climate simulations of seasonal & annual:

- Mean Temperature
-Total Precipitation
Baseline climatology

Baseline comparison

Temperature

Best seasonal representation
CCSR-NIES and ECHAM4

Good annual balance

HadCM3 and NCAR-PCM

Precipitation

Best seasonal
NCAR-PCM

Annual balance
GFDL-R30, NCAR-PCM and ECHAM4

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	Mean Temperature (°C) Baseline comparison				
Data Sets	Annual	Winter	Spring	Summer	Autumn
IDW	0.0	-17.3	0.3	15.3	1.5
CCSR-NIES	-1.8	-17.5	-5.0	14.4	0.9
CGCM1	3.0	-10.6	-0.4	16.8	6.1
CGCM2	1.2	-12.4	-3.4	14.9	5.8
CSIROMK2b	1.1	-13.6	-1.4	16.2	3.2
ECHAM4	1.5	-13.1	1.3	15.5	2.2
GFDL-R15	-1.0	-17.9	-3.2	16.7	0.2
GFDL-R30	3.1	-11.7	0.9	19.2	3.9
HadCM2	2.5	-10.0	2.8	14.3	2.8
HadCM3	-0.7	-16.8	0.4	14.1	-0.4
NCAR-DOE	6.1	-10.2	1.3	25.9	7.4
NCAR-PCM	-1.1	-16.5	-0.8	12.7	0.2

Yellow values = no significant difference

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	Total Precipitation (mm) Baseline comparison				
Data Sets	Annual	Winter	Spring	Summer	Autumn
IDW	469.2	64.9	90.1	208.9	105.3
CCSR-NIES	791.3	143.3	159.1	311.0	177.9
CGCM1	746.1	158.0	165.3	250.4	172.4
CGCM2	731.9	153.3	149.6	263.0	166.1
CSIROMK2b	656.6	101.6	132.9	279.7	142.4
ECHAM4	585.2	102.3	144.4	219.0	119.5
GFDL-R15	658.1	151.7	154.0	193.7	158.8
GFDL-R30	516.7	96.8	144.4	157.0	118.4
HadCM2	592.3	94.2	154.2	224.1	119.7
HadCM3	643.8	70.3	149.6	286.0	137.9
NCAR-DOE	778.5	148.5	245.2	201.3	183.5
NCAR-PCM	543.2	70.3	124.4	250.8	97.7

Meteorological Forcing and Downscaling

Current Climate forcing:

Surface Observations from Climate Archive

Precipitation (Daily) - 30 years 1961-1990

Temperature (Daily) - 30 years 1961-1990

700+ stations

Disaggregate (hourly) → Interpolated (Kriging) → Lapse rate

Interpolate (hourly) → Interpolated (Kriging)

Forcing for future climate: Apply basin mean changes in T and P due to GCM to observed data

GCM	%Precip	+Temp	Description
echa21	0.2	2.8	driest, warmest
echb21	-0.3	2.8	
hada21	11.1	2.3	moderately wet and warm
hadb21	6.1	2.1	
ncara21	11.8	1.7	wettest and least warm
ncarb21	8.5	1.5	

Season	% Precip	+Temp	Description
winter	11.8	2.1	wetter and warmer
spring	9.1	1.3	wetter and somewhat warmer
summer	-3.8	3.0	drier and much warmer
fall	7.9	2.3	wetter and warmer

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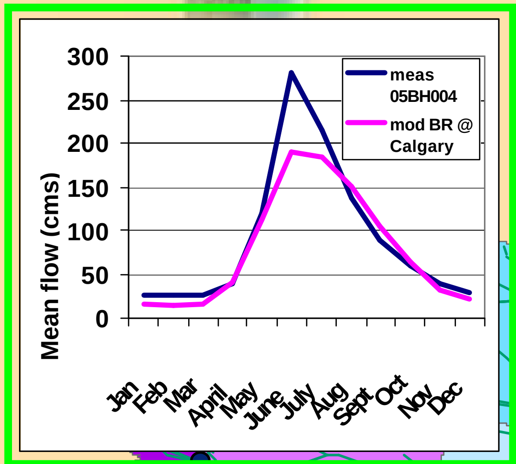
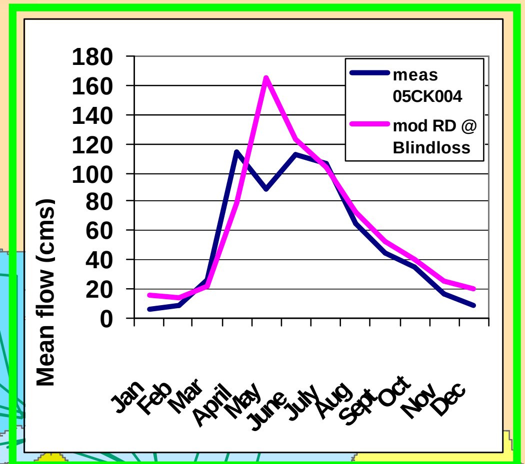
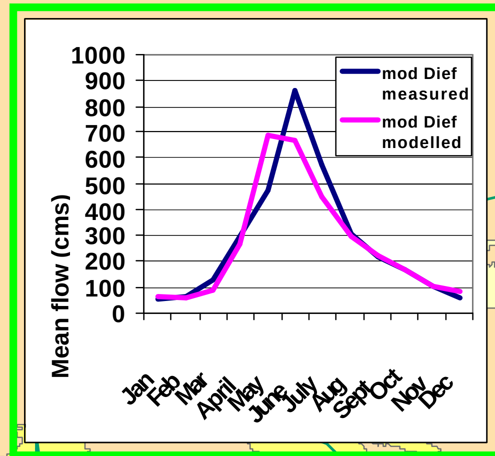
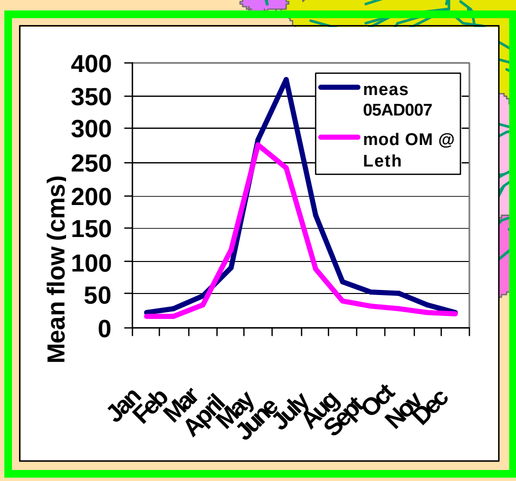
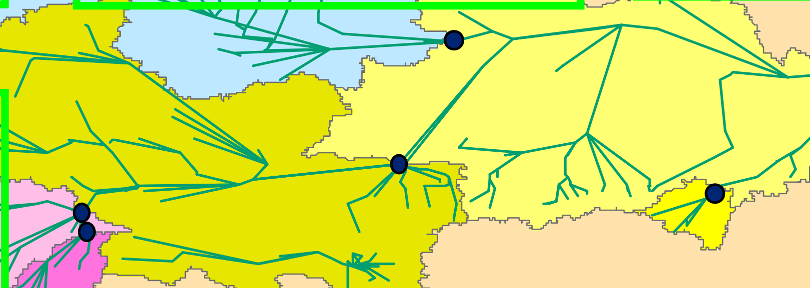
Modeling results 1961-90
Watflood - MISBA





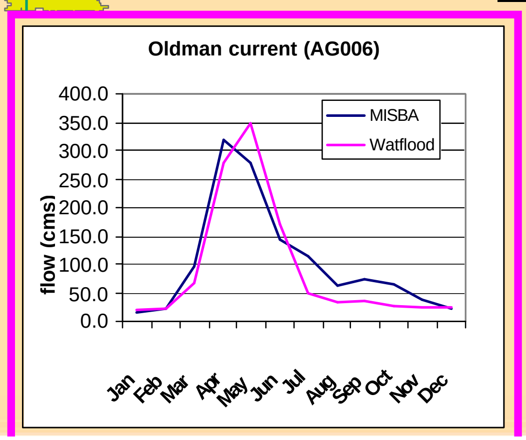


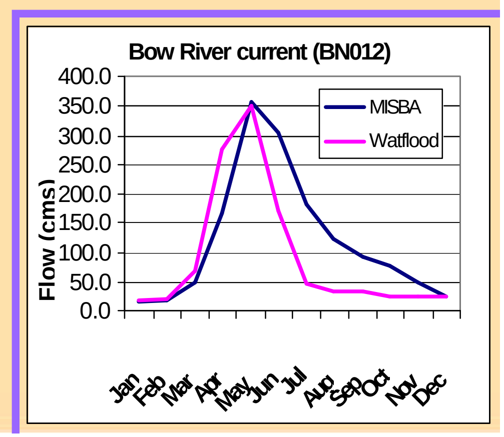




Mean annual flows cms

	Oldman (05AG006)	Bow River (05BN012)
Observed	104.6	122.1
MISBA	103.9	121.4
Watflood	91.4	106.8





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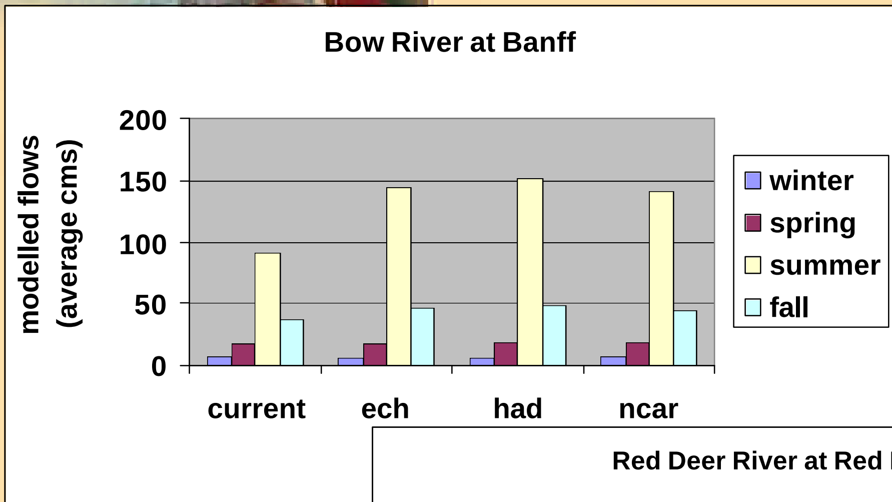
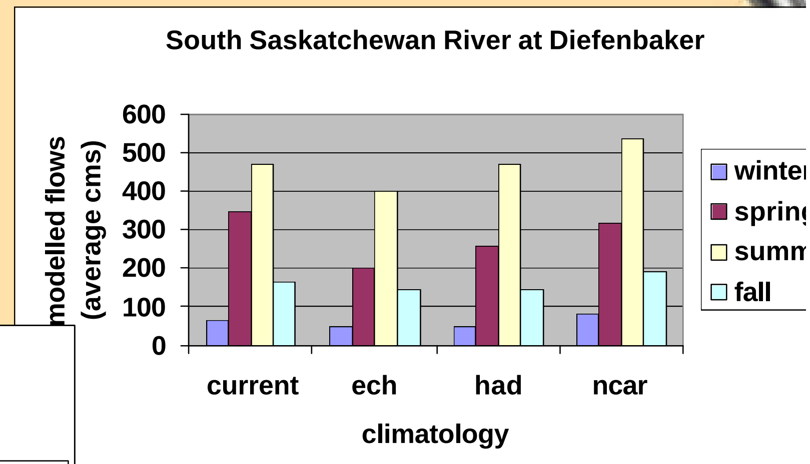
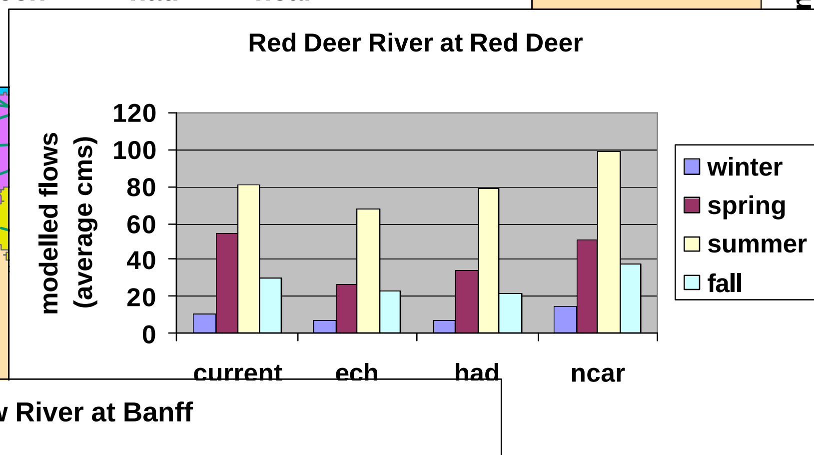
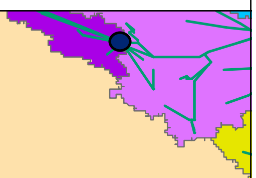
Seasonal response in future flows









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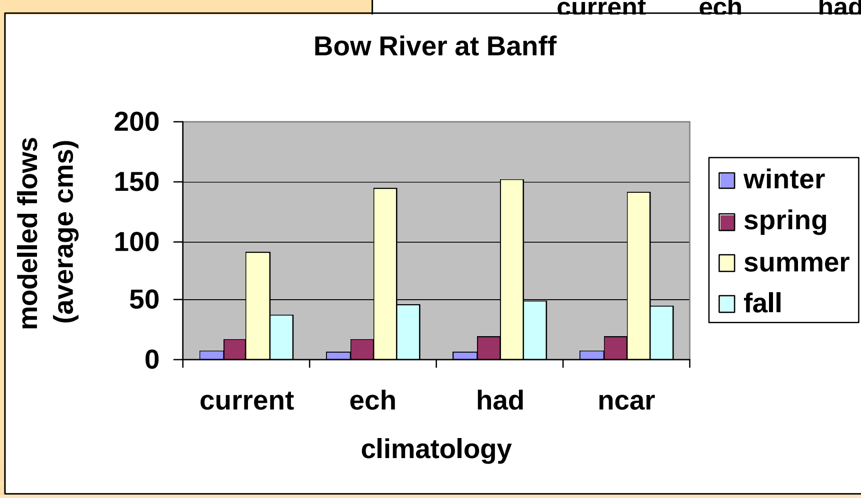

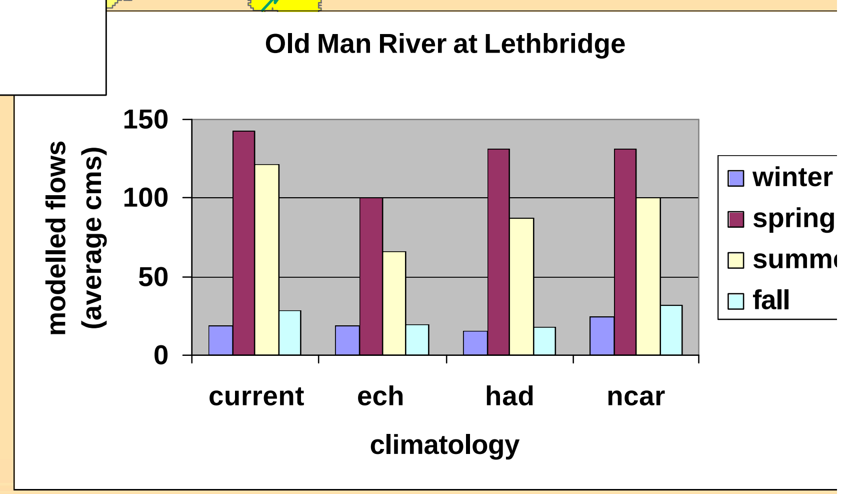

Uncertainties……
or
Confessions of a modeler

- **"The greatest obstacle to discovery is not ignorance, it is the illusion of knowledge". -** Daniel Boorstin
- **Prairie Hydrology is poorly understood!!!**
- **Data uncertainties**
- **Non-contributing area**
- Effect of land-use practices
- Groundwater
- The role of glaciers
- The role of potholes and depression features in the water and energy balance
- Snow sublimation
- Seasonally frozen soils
- ET estimates are uncertain

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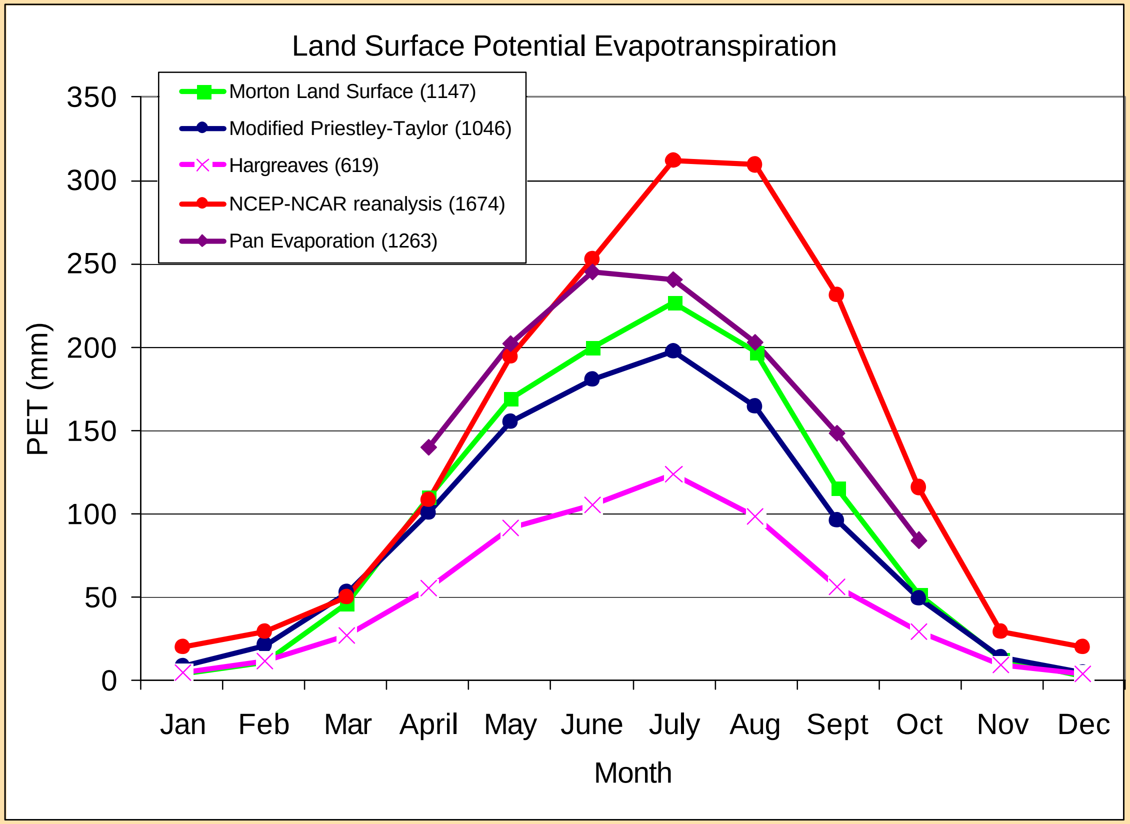
PET estimates available to link to distributed hydrologic modeling



- **Morton/CRAE**
  - Spatially and temporally insufficient
- **Modified Priestley-Taylor**
  - Estimates end at Alberta border
- **NCEP/NCAR re-analysis data**
  - Sufficient spatial/temporal resolution
- **Hargreaves within Watflood**
  - Can be modified/recoded
  - Must ensure consistency

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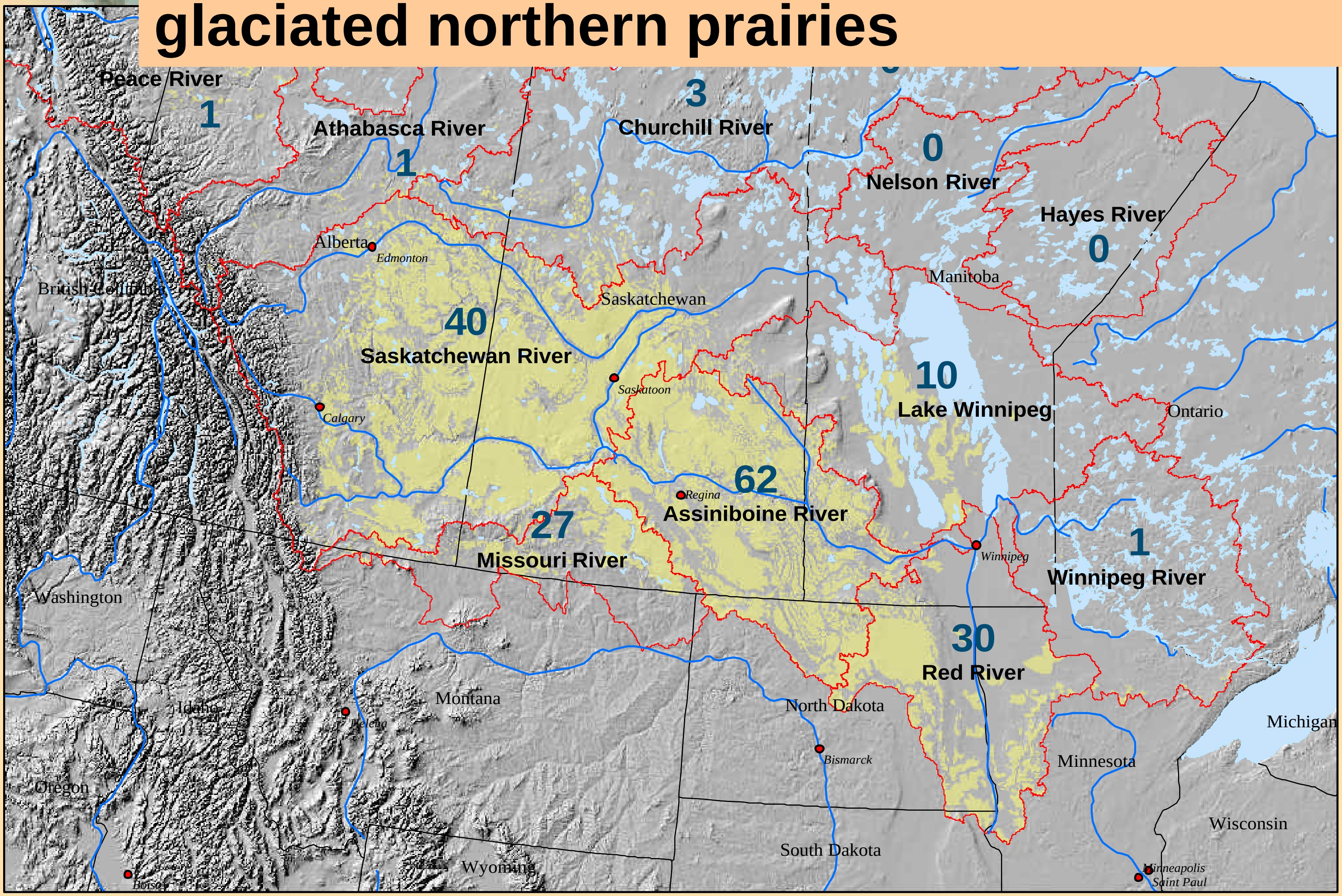
Closed basins of the glaciated northern prairies



Source: Non-contributing area - Agriculture and Agri-Food Canada, P.F.R.A.
Elevation data - Environmental Systems Research Institute

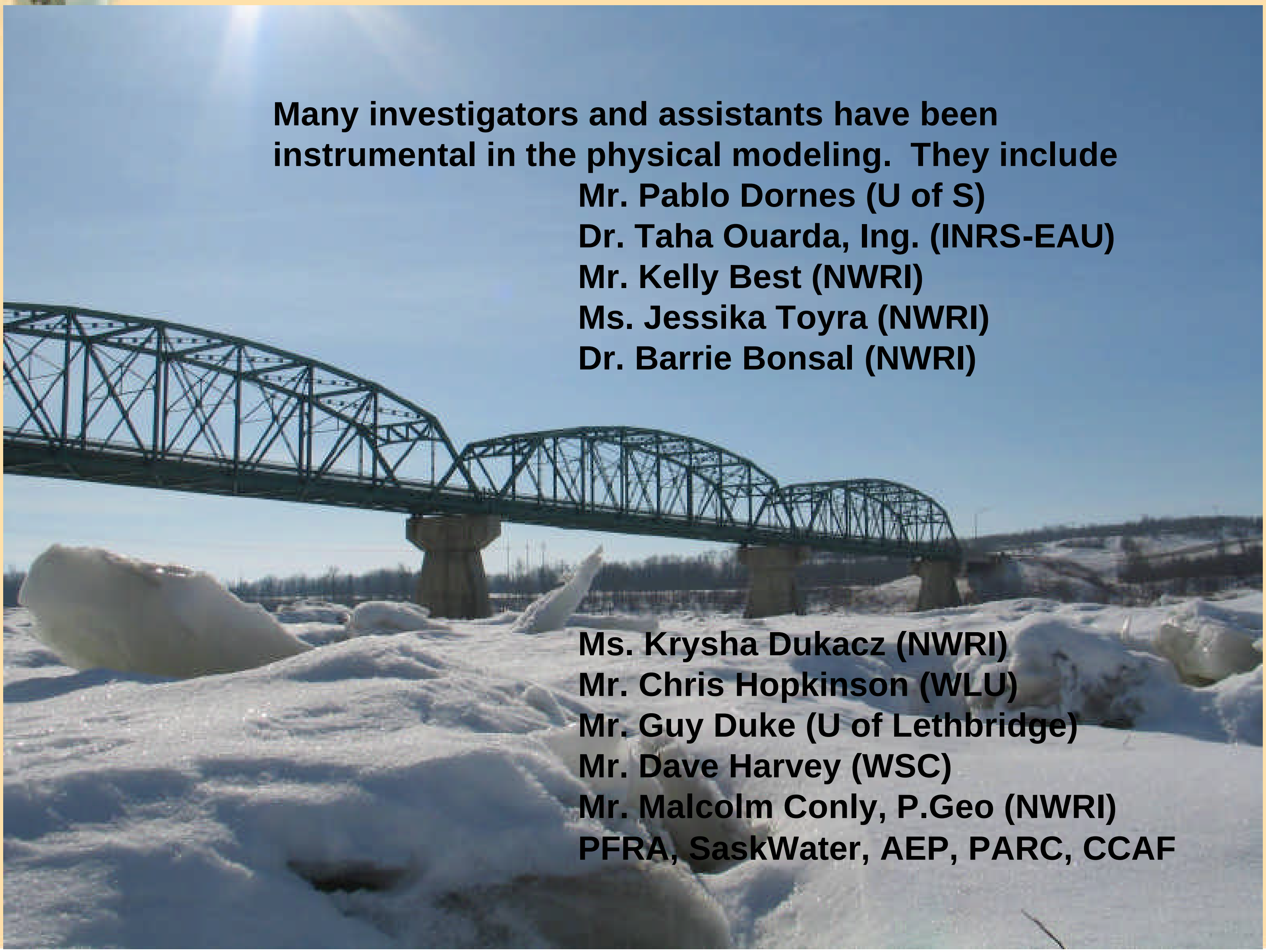
0 50 100 200
Kilometers

SSRB Water Availability Study – physical modeling and linkages

- **The Physical Component of the SSRB climate change study nearing completion**
  - Comparison with Sacramento, MISBA for major sub-basins
    Cross validation/nested scaling
  - Model output linked to economic analysis on a yearly and sub-basin scale

- **Where to go, implications for DRI**
  - Continued evaluation on other components of the water cycle
    - Potential evapotranspiration (PET), AET/soil moisture availability
    - Closed basins, non-contributing areas
  - Assessment of uncertainties with further examination of current climate modelling or within GCM scenarios

- **SSRB has striven for a unique and consistent approach to quantifying socio-economic impacts using solid physical models and methodologies.**



Many investigators and assistants have been instrumental in the physical modeling. They include

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Mr. Dave Harvey (WSC)
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