UNIVERSITY OF SASKATCHEWAN

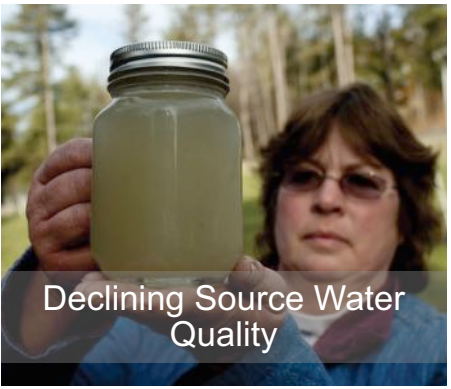
Global Institute for Water Security

www.usask.ca/water

# The Changing Cold Regions Network - Integrating Disciplines across Regions to Deliver New GEWEX Science

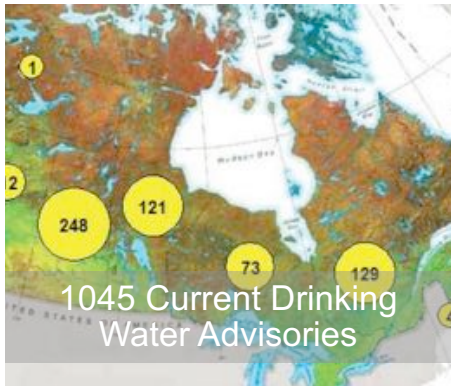
***Howard Wheater,*** *Founding Director, GIWS & Global Water Futures*

# Canada's Water is at Risk


Declining Source Water Quality

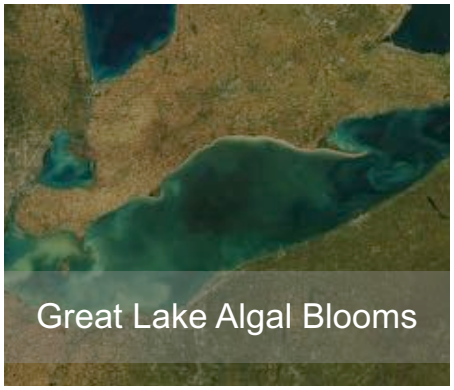

Toronto Flood (2013)


Legacy Mine Waste



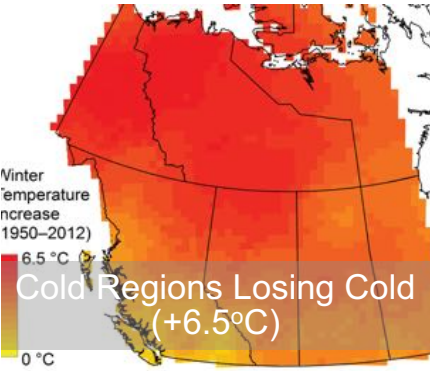
1045 Current Drinking Water Advisories


Calgary Flood (2013)


Great Lake Algal Blooms


Drought: Prairies (1999-2004)

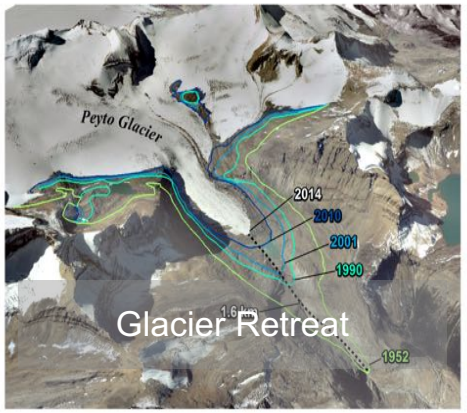
# The Big Thaw



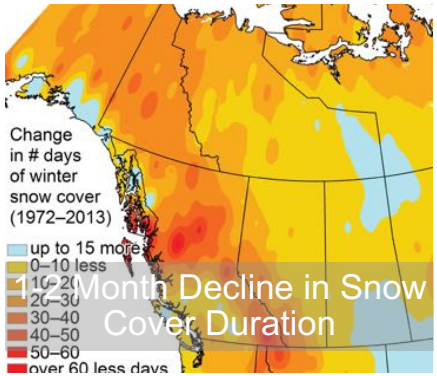
Cold Regions Losing Cold (+6.5°C)


Permafrost Thaw


Unprecedented Prairie Summer Flooding



Glacier Retreat



1 Month Decline in Snow Cover Duration

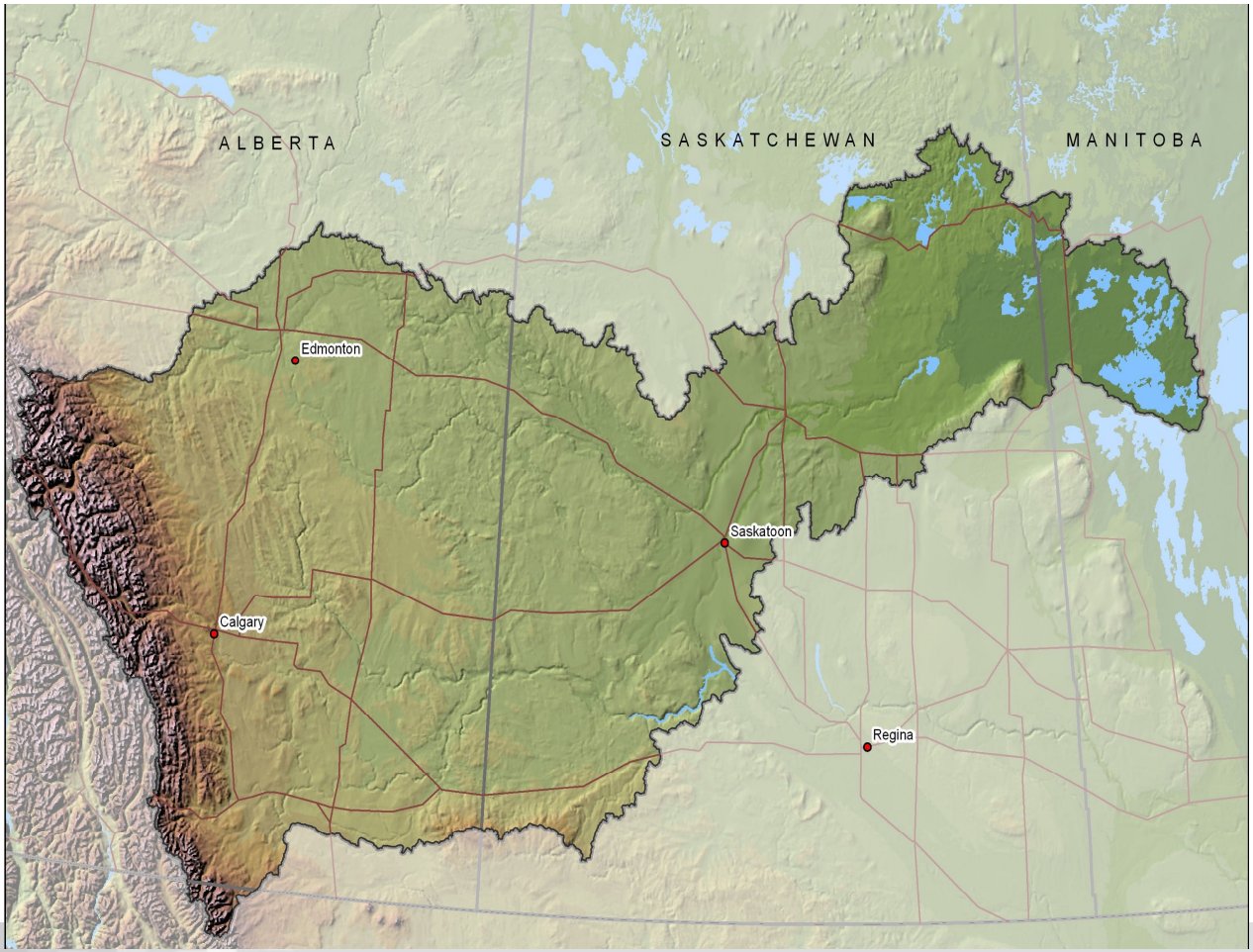

Extreme Wildfires


Yukon's Slims River Changes Flow Direction

# Adaptation to change requires:

- **New science** to understand the changing Earth system
- **New modelling tools** to capture interconnected forces and their societal implications
- **New monitoring and forecasting systems** to warn of critical environmental changes
- **More effective mechanisms to translate new scientific knowledge into societal action** e.g. computer apps, games, visualization tools

# Saskatchewan River Basin





Area 406,000 km$^2$

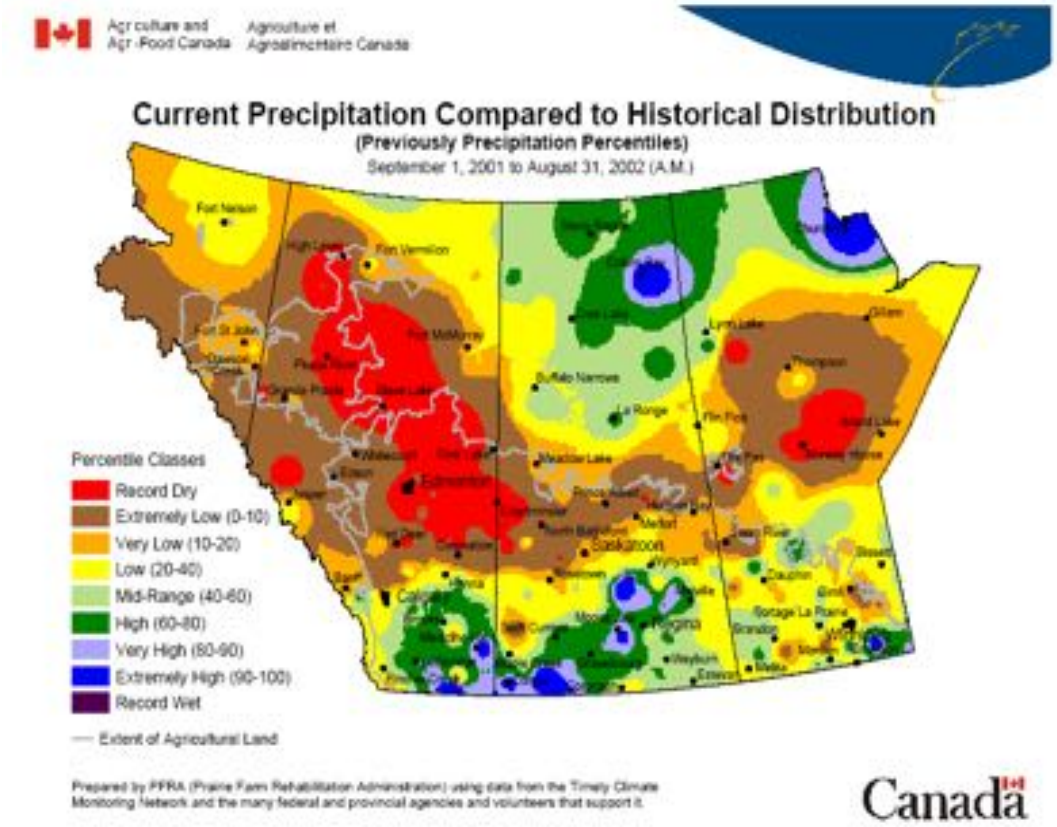
- Drains from continental divide in Alberta, through Saskatchewan to Manitoba

# Management issues include:

- The South Saskatchewan river has reached limits for water use in southern Alberta
- Climate change and land management are changing the land and its water in complex ways, affecting river flows and prairie hydrology
- Pollution is changing water quality
- Extreme events are damaging and set to increase
- Water governance is complex and fragmented

# Prairie Drought of 1999-2004

## Described as Canada's most costly natural disaster




- $5.8 billion decline in GDP 2001-2002
- $3.6 billion drop in agricultural production, 2001-2002
- 41,000 jobs lost
- BC, Alberta forest fires
- Saskatchewan dust storms

# Calgary floods June 2013

5 deaths, 100,000 evacuated,$6 billion direct damages

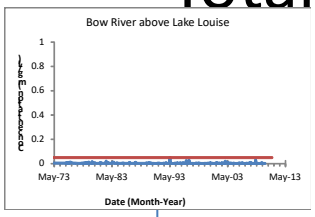
City of Calgary

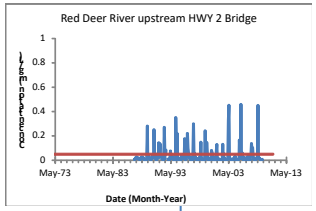
Town of Canmore

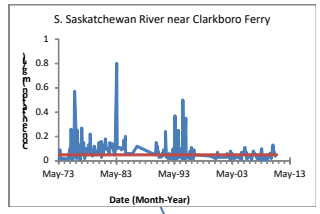
# Total Phosphorous Concentration (1973-2009)

Concentration (mg/l)

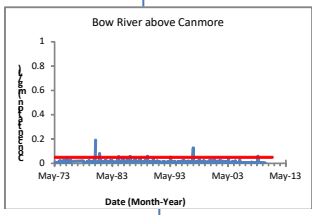
AB Surface Water Quality Guideline (0.05 mg/l)



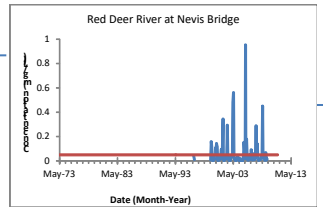



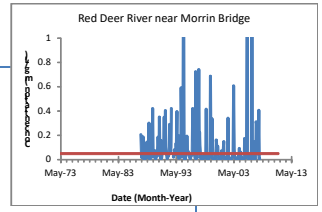



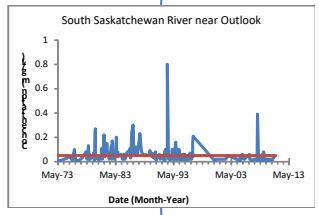

Saskatoon



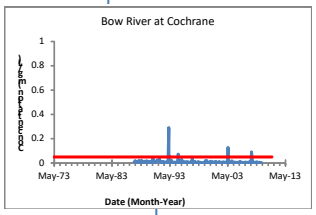

Red Deer



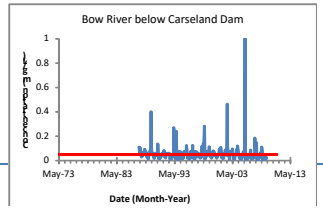

South Saskatchewan River

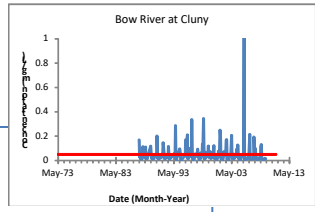


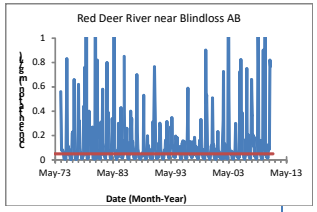

Bow River

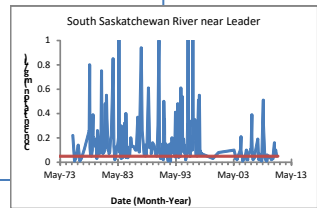
Red Deer River

L. Diefenbaker

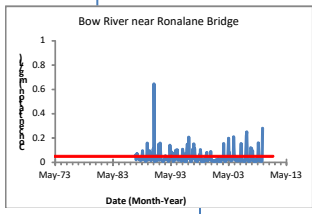


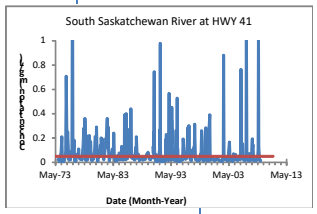



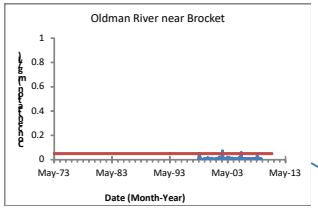



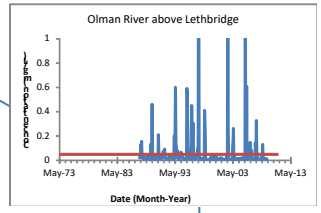

Calgary



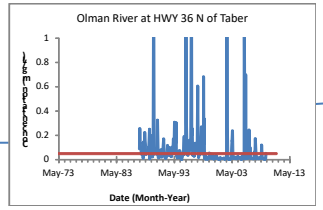



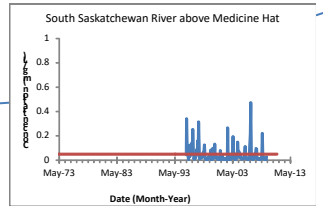




Oldman River




Medicine Hat



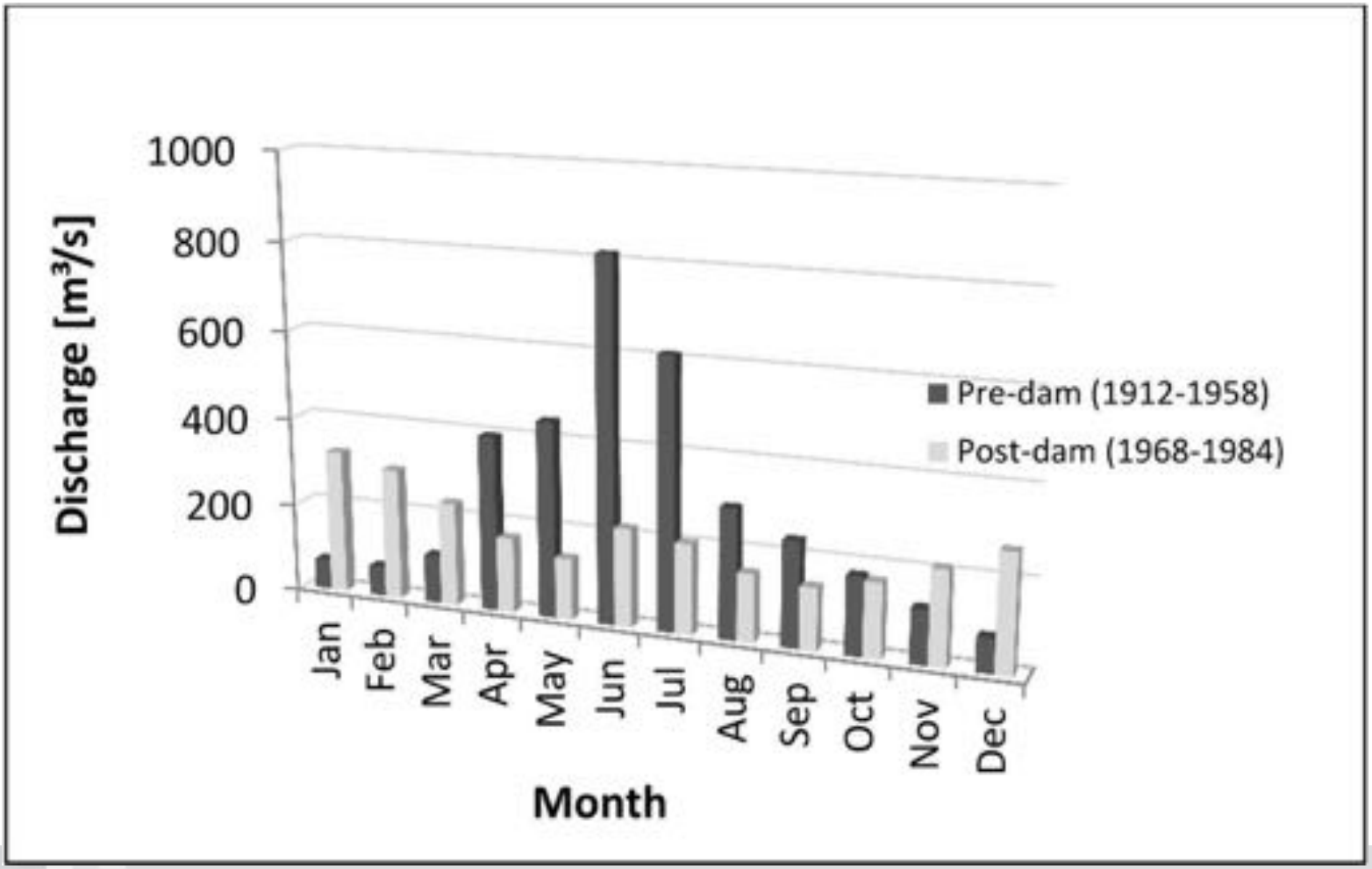




Lethbridge

# Effects of agricultural management?

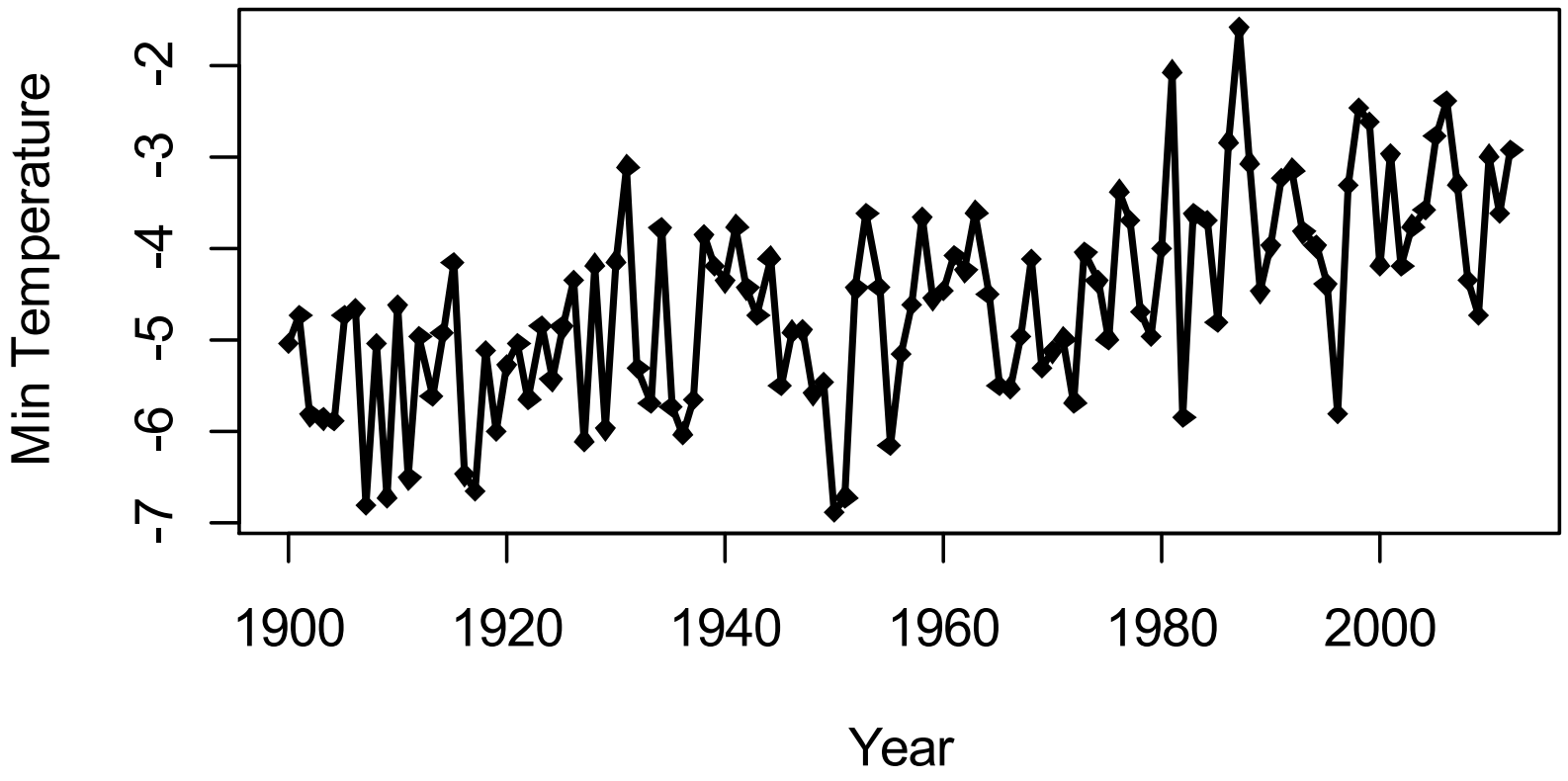
## Smith Creek, SK

# South Saskatchewan annual hydrograph: pre- and post-dam construction



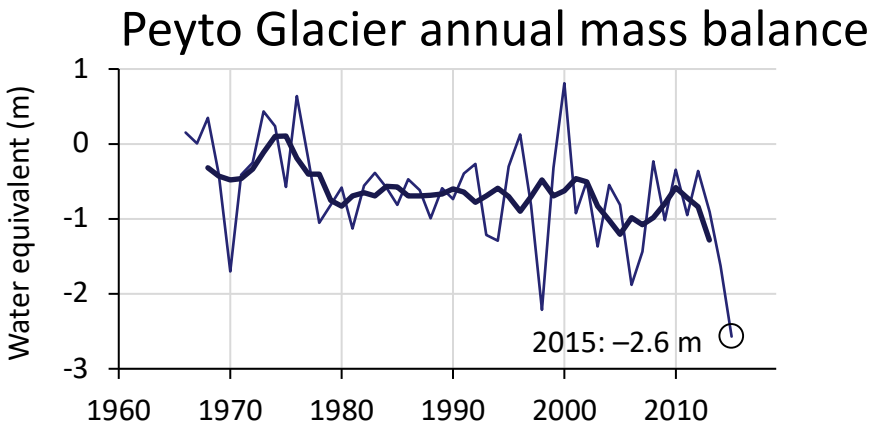
# Warming climate – glacier retreat, changing snow accumulation/melt, rain/snow balance

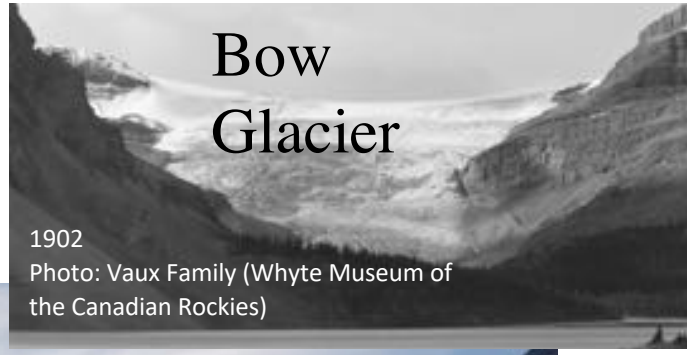
## SaskRB Spatially-averaged Minimum Temperature Trends

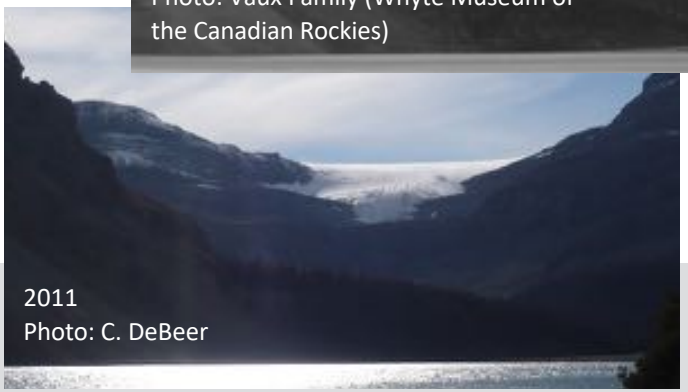


# Mountain Glaciers and Ice Fields

- Widespread glacier retreat across western Canada and globally
- Predominantly negative net mass balance—record ice loss in 2015 for many glaciers
- Many glaciers have exhibited an acceleration of their retreat and disintegration in the very recent past
- The ability of glaciers to augment flows leaving the Rockies is low—e.g. very lows flows last year despite record negative mass balance



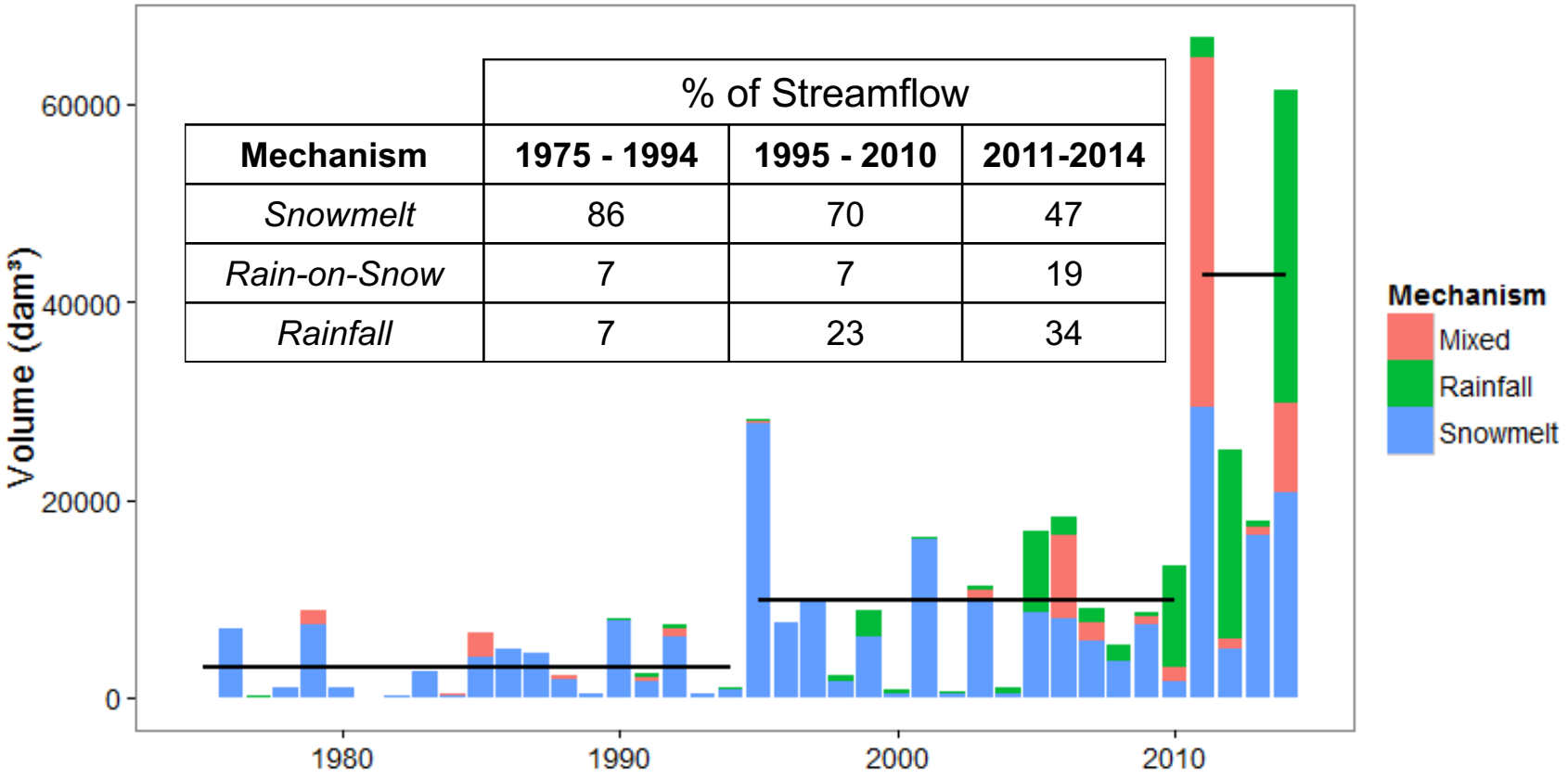



# Prairie Streamflow - Smith Creek SK

## Annual Flow

| | % of Streamflow | | |
|---|---|---|---|
| **Mechanism** | **1975 - 1994** | **1995 - 2010** | **2011-2014** |
| *Snowmelt* | 86 | 70 | 47 |
| *Rain-on-Snow* | 7 | 7 | 19 |
| *Rainfall* | 7 | 23 | 34 |




Source: Dumanski et al., 2015

# GIWS Saskatchewan River Basin Observatory

## - a GEWEX Regional Hydroclimate Project 2011-


Area 406,000 $km^2$

Drains from continental divide in Alberta, through Saskatchewan to Manitoba and Hudson's Bay

Wheater, H.S. and Gober, P. 2015. *Water Resour. Res.,* **51**: 5406-5424

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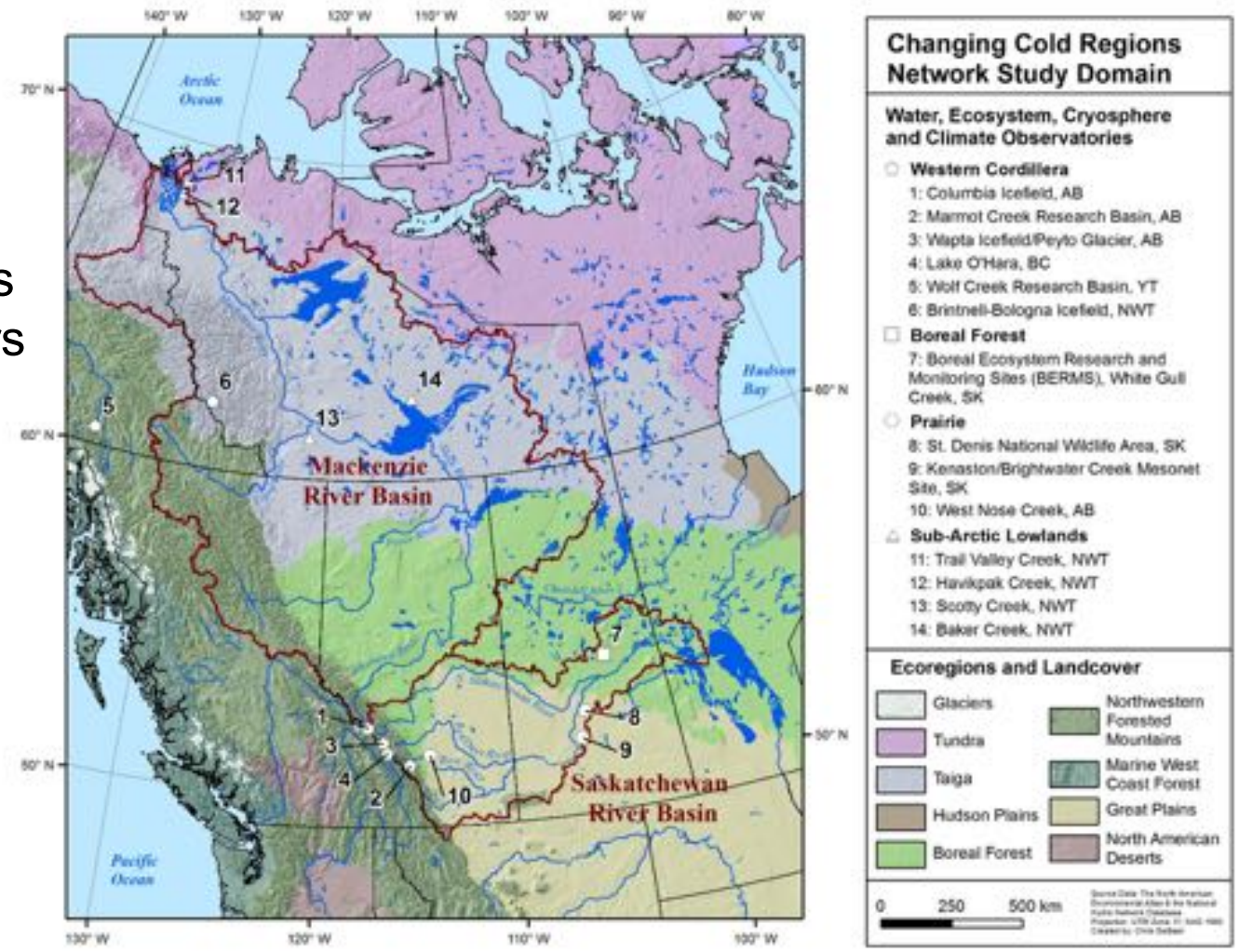
# Changing Cold Regions Network
## 2013-2018

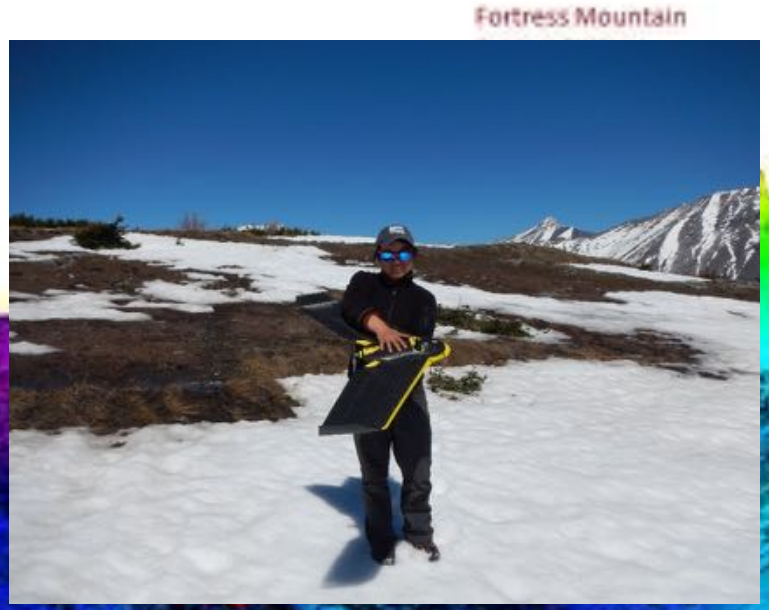
8 universities
4 federal agencies
43 co-investigators
- links to multiple international programs and partners

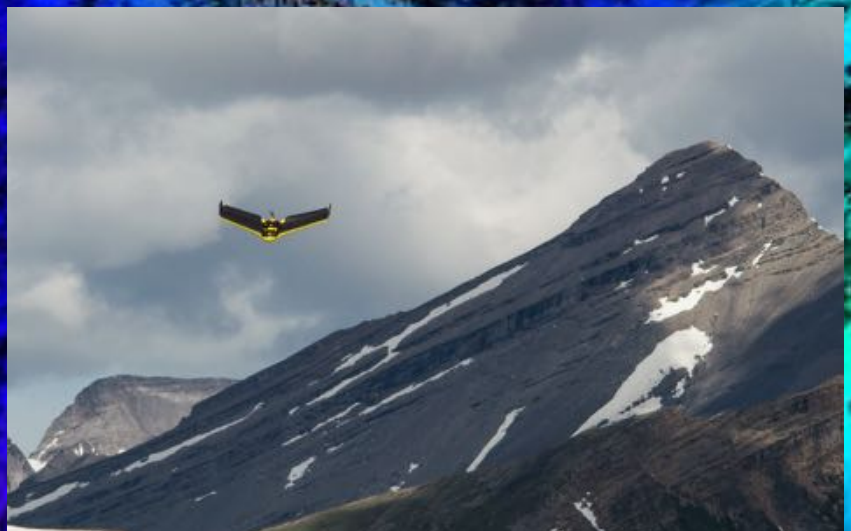


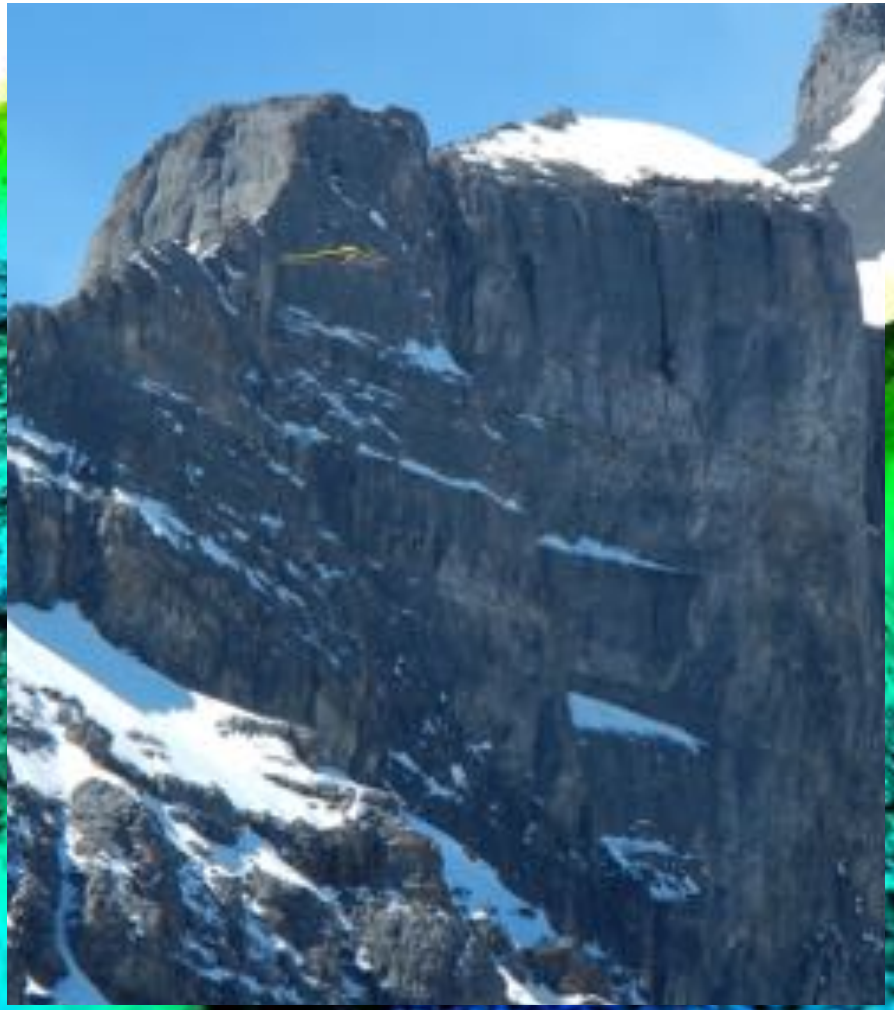
# CCRN Research:

- Observed Earth System Change in Cold Regions—Inventory and Statistical Evaluation;
- Improved Understanding and Diagnosis of Local-Scale Change;
- Improved Atmospheric Modelling and River Basin-Scale Simulation;
- Analysis and Prediction of Regional and Large-Scale Variability and Change; and
- User Community Outreach and Engagement

# SnoDrone – Fortress Mountain Snow Lab

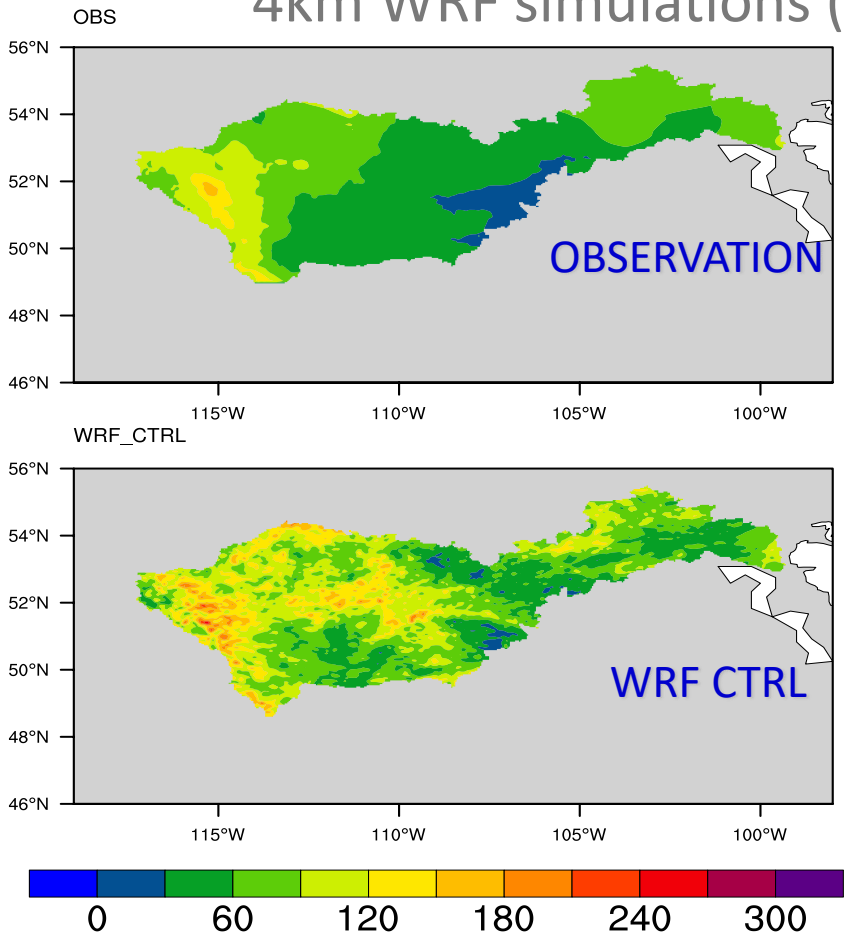


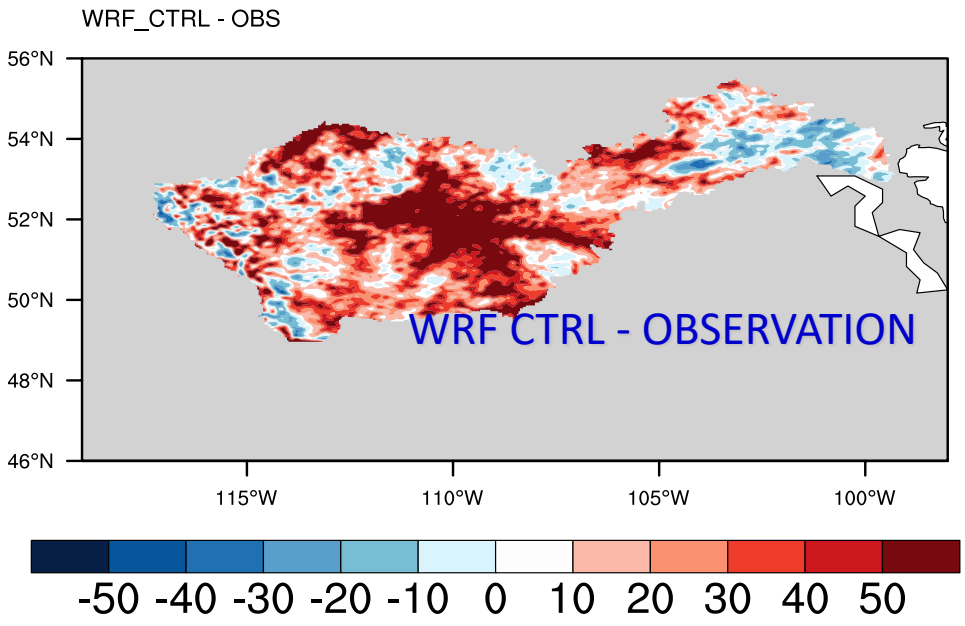





# High resolution atmospheric modelling

## 4km WRF simulations (Yanping Li, Roy Rasmussen)

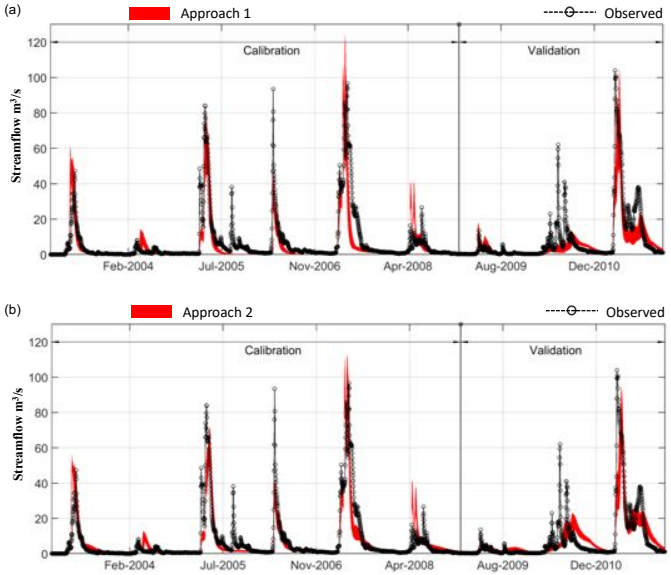


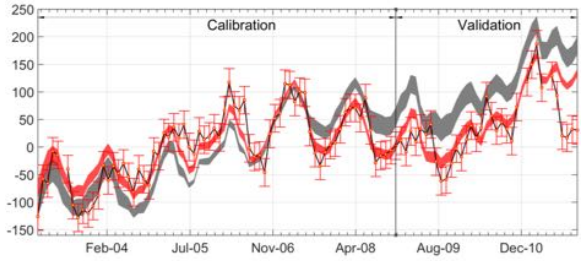

SRB (Precipitation June 2001)

# Large Scale Hydrological Modelling

## Use of GRACE data to constrain model parameters in MESH

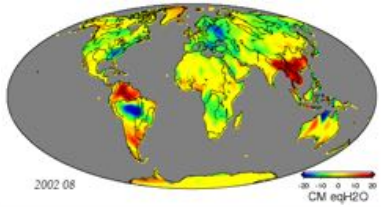


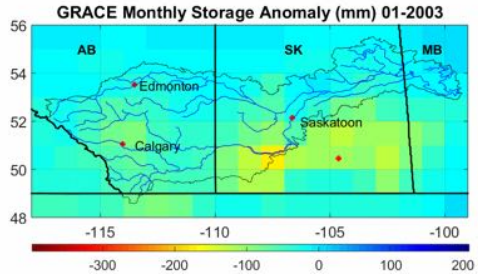

Streamflow comparisons

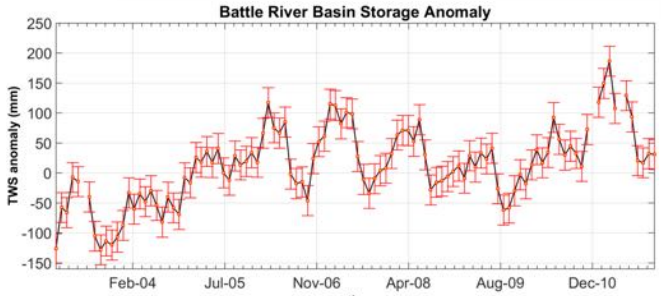



Calibration and validation of TWS anomaly

***GRACE** satellite*
*(Photo credit: NASA)*



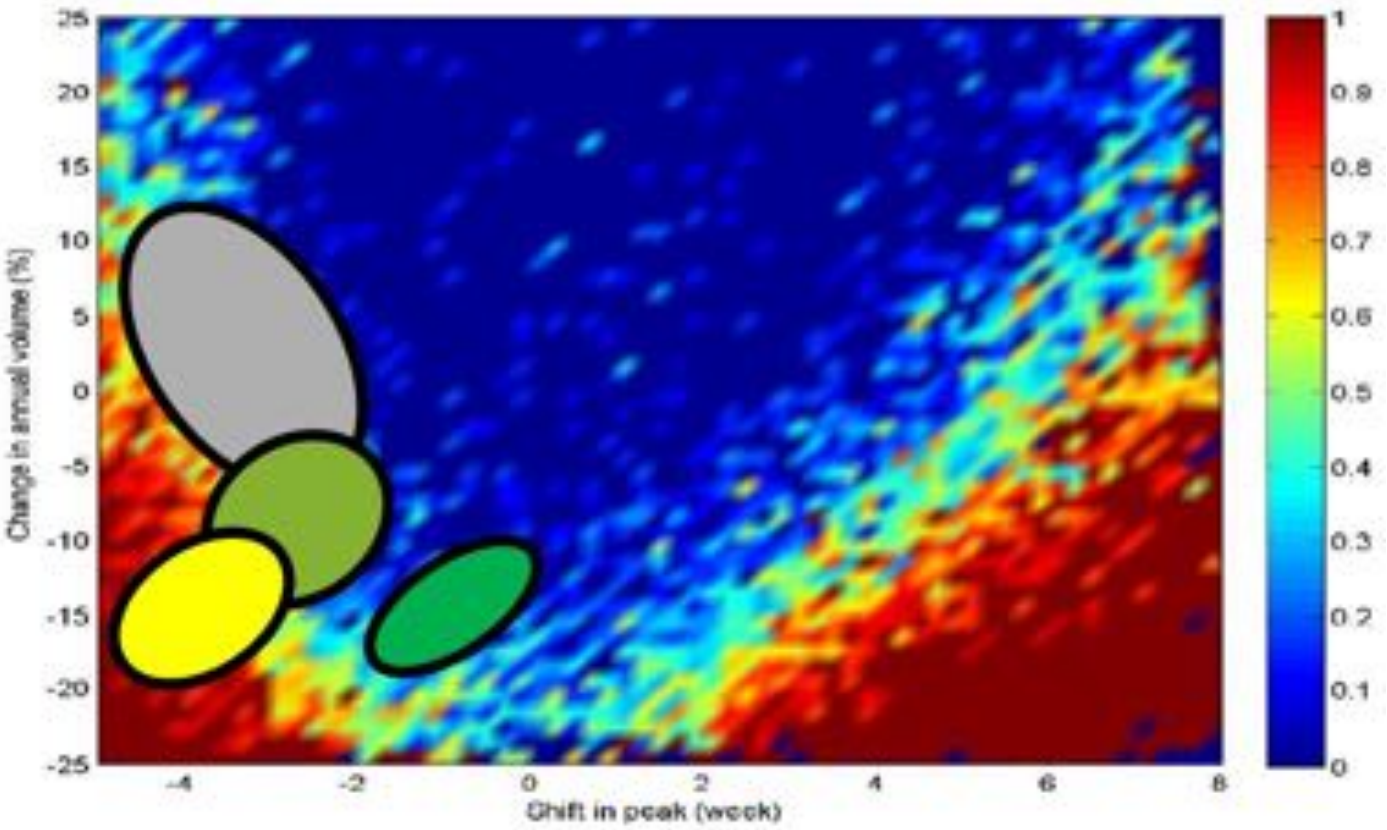

GRACE total water storage (TWS) anomaly

- Use of GRACE data helps to facilitate parameter identifiability and improve results

# Water resource vulnerability – SSR, Alberta

Probability of system failure under changing headwater flows (annual peak, Peak timing)

Nazemi et al. 2013

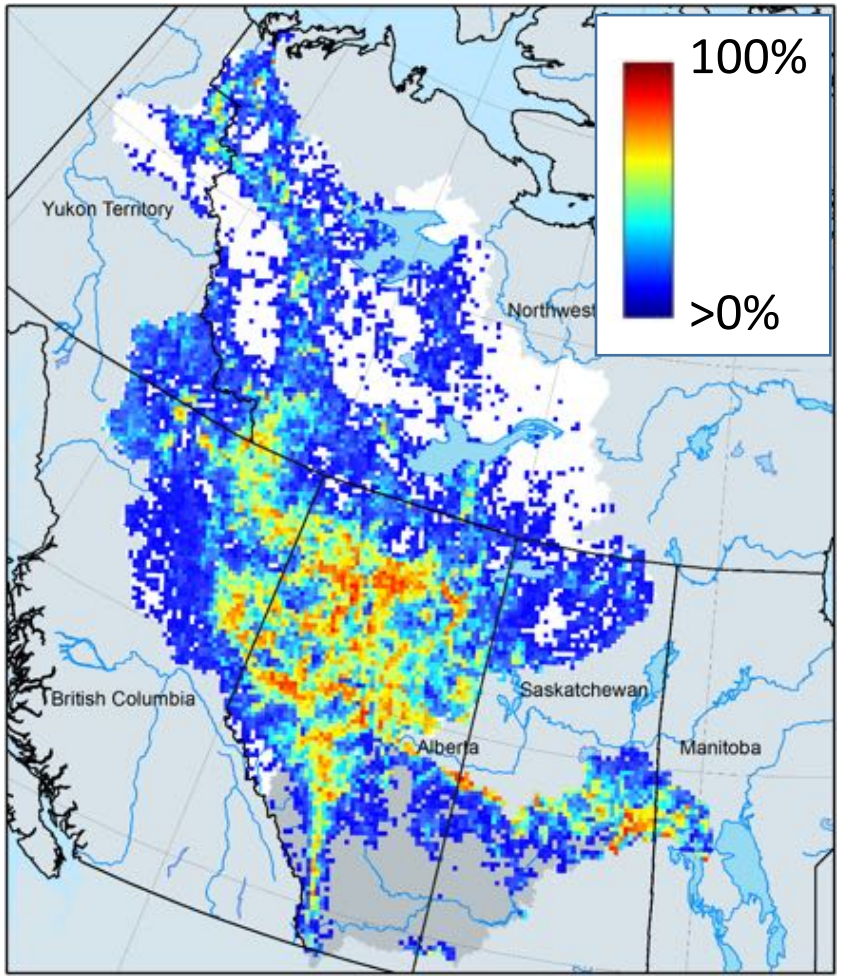


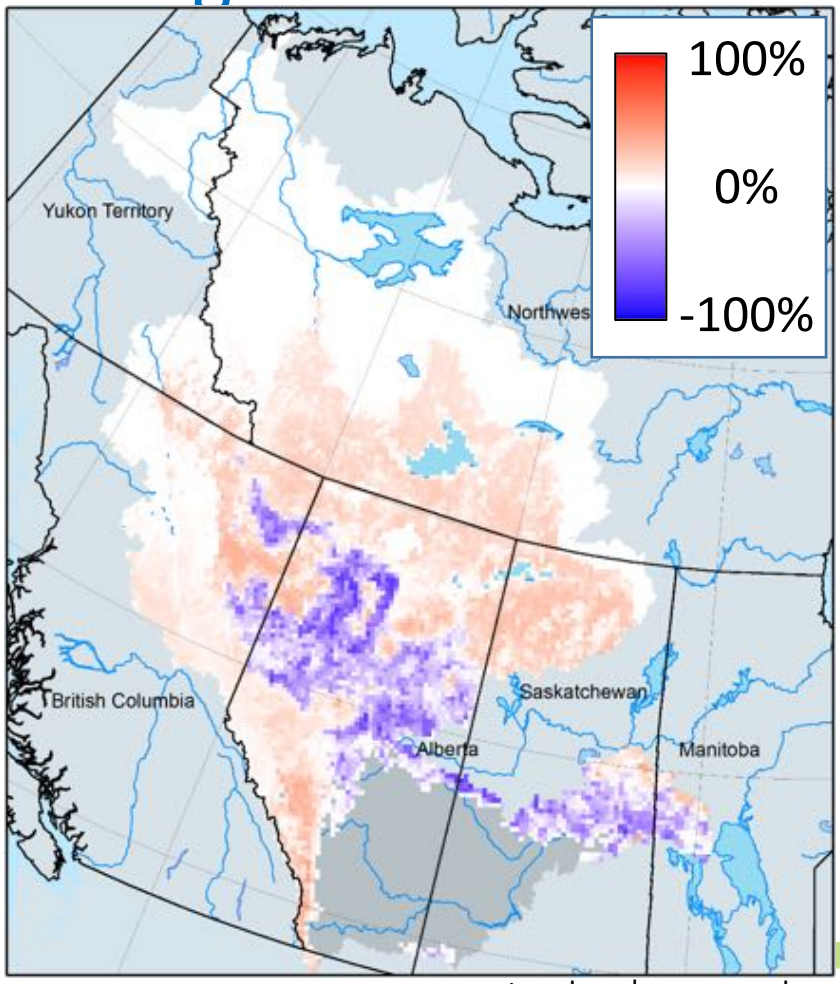
# Scenarios of change

## e.g. Mixedwood Forest: Displacing Evergreen Forest After Fire, Displaced by Cropland

2005

%Change 2005 to 2085

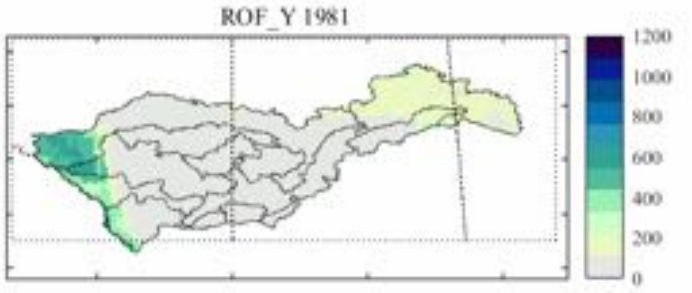


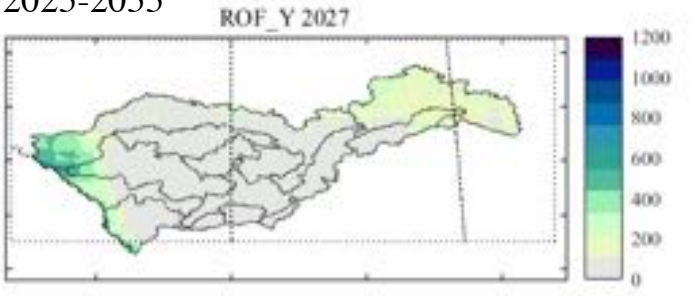
# Saskatchewan River Basin – Changes in Streamflow

1970-2010 2025-2055 2070-2100

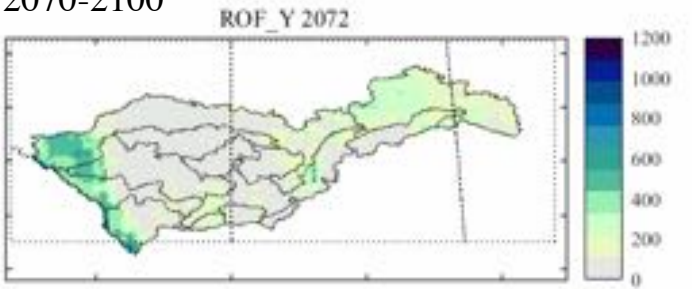
1970-2010



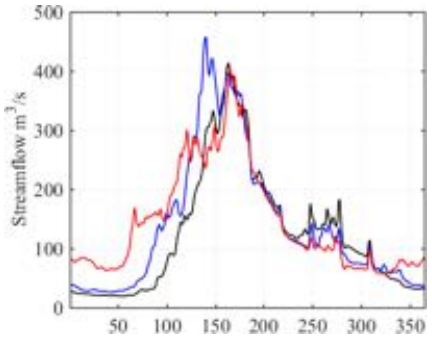

2025-2055



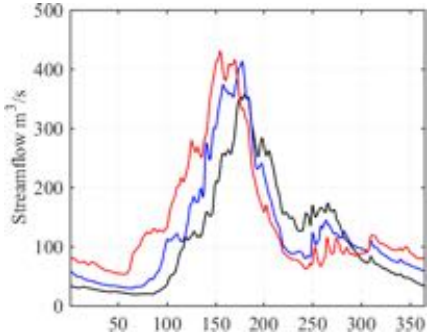

2070-2100



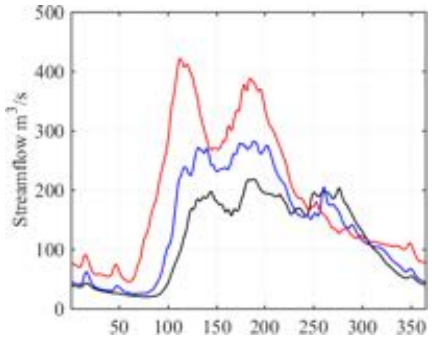

Oldman near the mouth



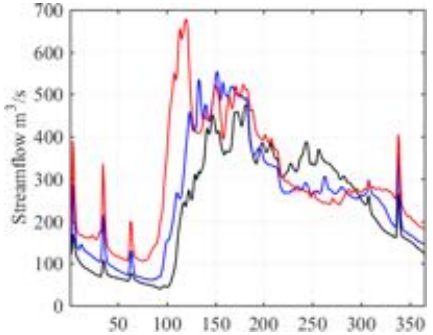

Bow near the mouth



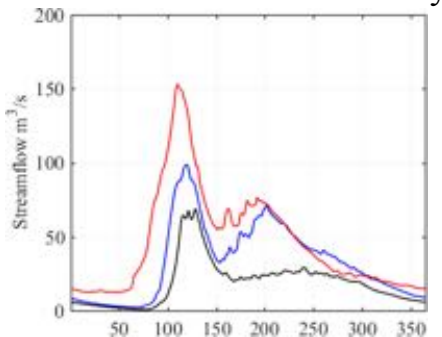

Red Deer near Bindloss



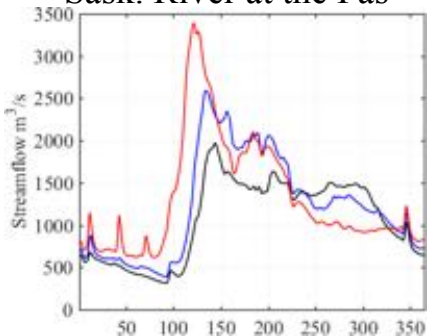

N. Sask @Edmonton



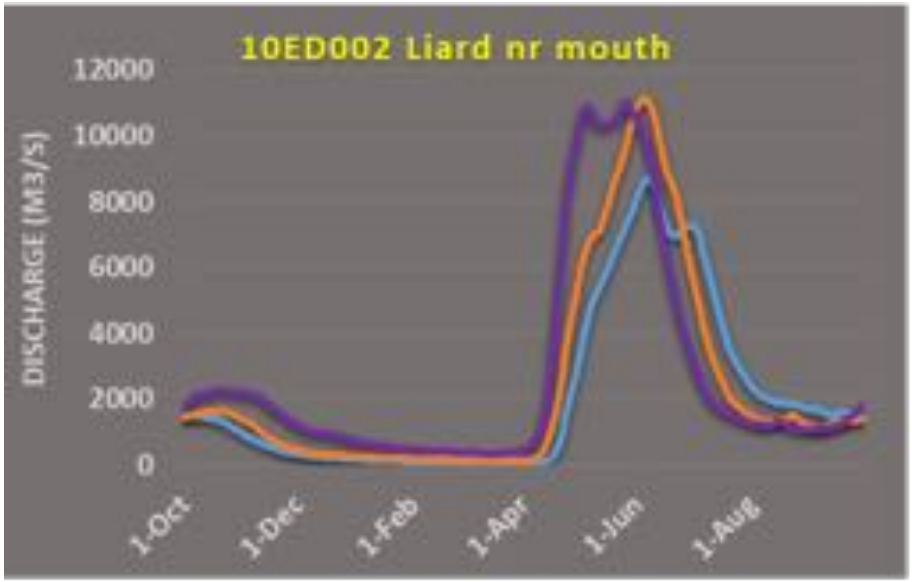

Battle near Sask boundary

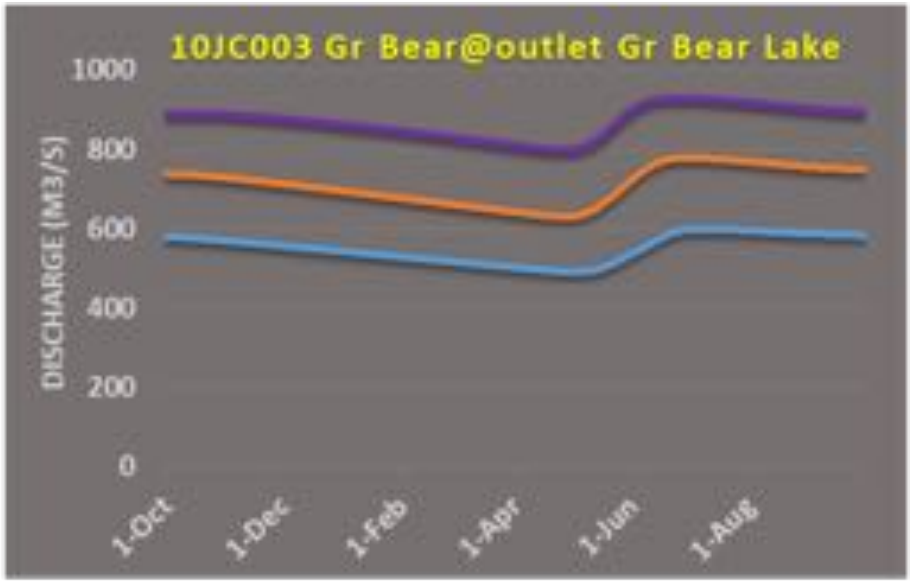



Sask. River at the Pas

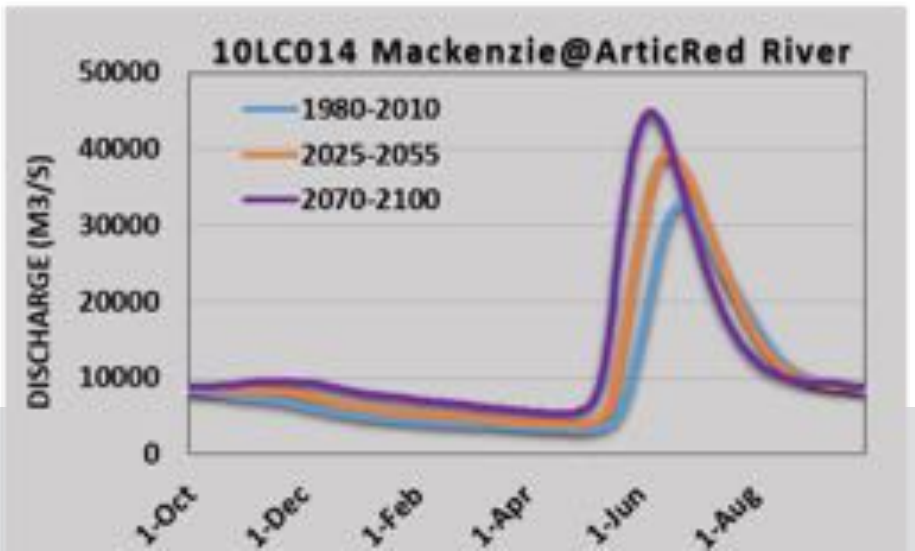


# Mackenzie Basin- Changes in streamflow







# Downstream

– a play by Kenneth T. Williams

# Delta Dialogue

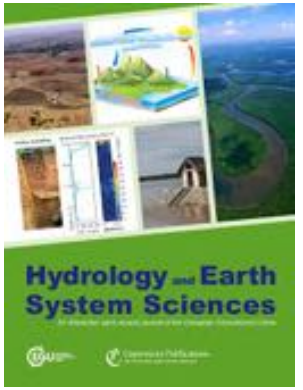
- a travelling display

# Community-based monitoring

Training trainers for fish health monitoring, Slave River Delta, North West Territories

# Special Issue Journals

- CCRN has opened two separate special issues in the EGU journals *Earth System Sciences Data (ESSD)* and *Hydrology and Earth System Sciences (HESS)*
- **ESSD Special Issue: *Water, ecosystem, cryosphere, and climate data from the interior of Western Canada and other cold regions***
  - Editors: C. DeBeer, W. D. Helgason, and P. Marsh
  - https://www.earth-syst-sci-data.net/special_issue901.html
  - Start date: 1 May, 2017; End date: 31 May, 2018
- **HESS Special Issue: *Understanding and predicting Earth system and hydrological change in cold regions***
  - Editors: S. Carey, C. DeBeer, J. Hanesiak, Y. Li, J. Pomeroy, B. Schaefli, M. Weiler, and H. Wheater
  - https://www.hydrol-earth-syst-sci.net/special_issue919.html
  - Start date: 1 June, 2017; End date: 1 September, 2018

# CCRN as a GEWEX RHP has delivered:

- New data
- Improved fine scale and large scale models
- New insights into past and future change
- 285 refereed publications (so far)
- 318 media interviews and op-eds
- Trained 388 students and 398 other HQP

- **For the movie and further information**, see: www.ccrnetwork.ca

# Conclusions

Water Security in the 21st century raises critical challenges for society and for science. We need:

- Trans-disciplinary science
- Science-society connection
- Integration across scales

GEWEX RHPs have shown that large-scale initiatives can develop new science, integrate disciplines and make essential connections with user communities.

**GEWEX has a critical role to deliver the new science needed at regional and global scales.**

# Water means the WORLD to Us...

UNIVERSITY OF SASKATCHEWAN

Global Institute for Water Security

www.usask.ca/water