Introduction to Global Water Futures

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September 14, 2017

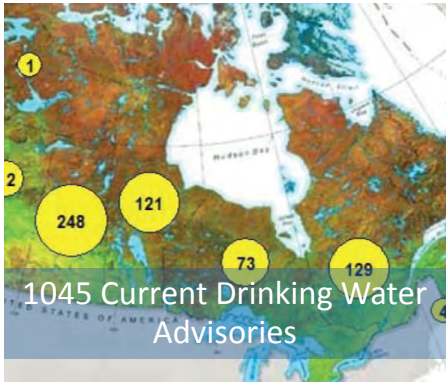
UNIVERSITY OF SASKATCHEWAN
Global Water Futures
GWF.USASK.CA

Our Water is at Risk


Declining Source Water Quality

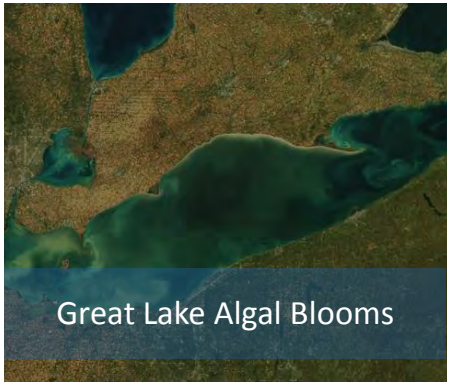

Toronto Flood (2013)


Legacy Mine Waste



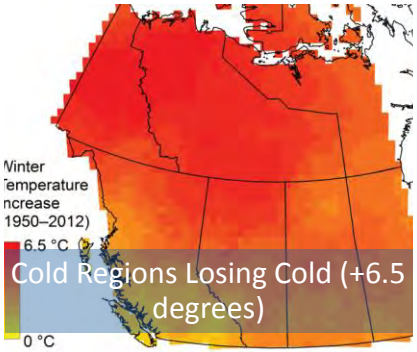
1045 Current Drinking Water Advisories


Calgary Flood (2013)


Great Lake Algal Blooms


Drought: Prairies (1999-2004)

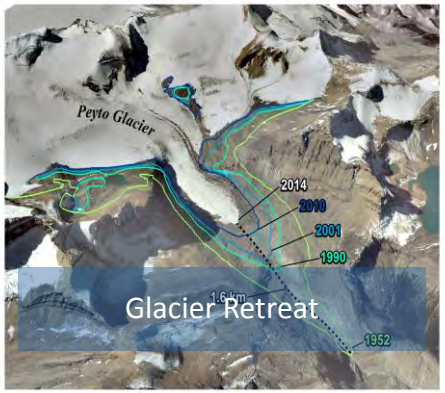
The Big Thaw



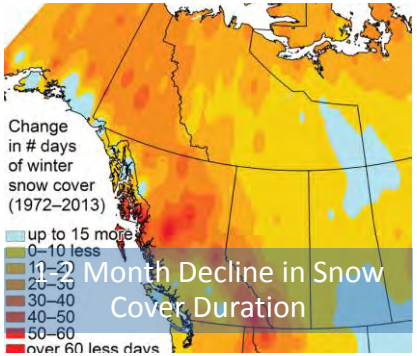
Cold Regions Losing Cold (+6.5 degrees)


Permafrost Thaw


Unprecedented Prairie Summer Flooding



Glacier Retreat



1-2 Month Decline in Snow Cover Duration


Extreme Wildfires


Yukon's Slims River Changes Flow Direction

Adaptation to change and threat mitigation requires

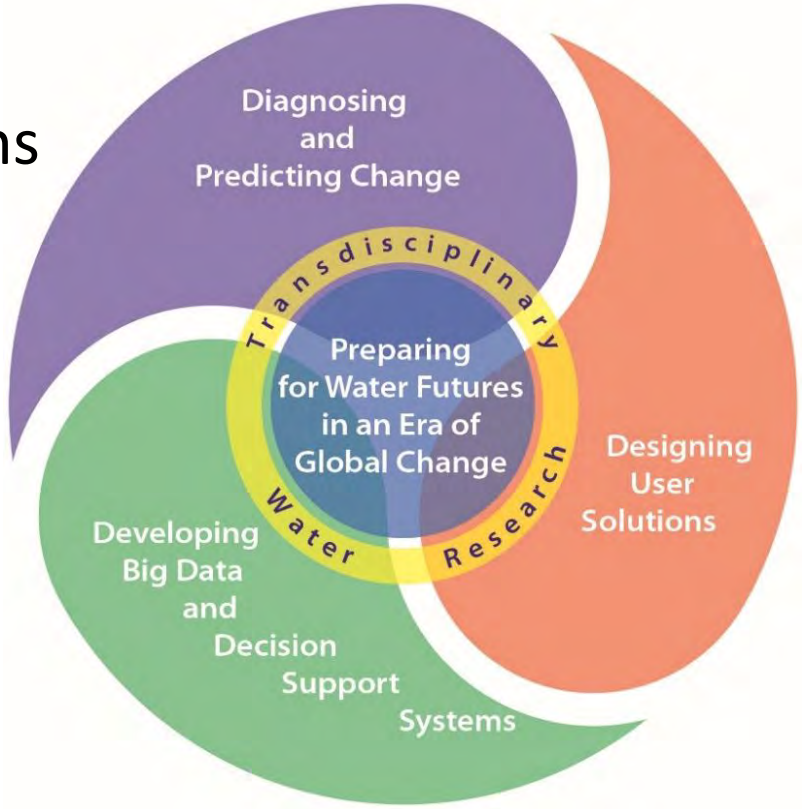
- **New science** to understand the changing Earth system
- **New modelling tools** to capture interconnected forces and their societal implications
- **New monitoring systems** to warn of critical environmental changes
- **More effective mechanisms to translate new scientific knowledge into societal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

Global Water Futures - Mission

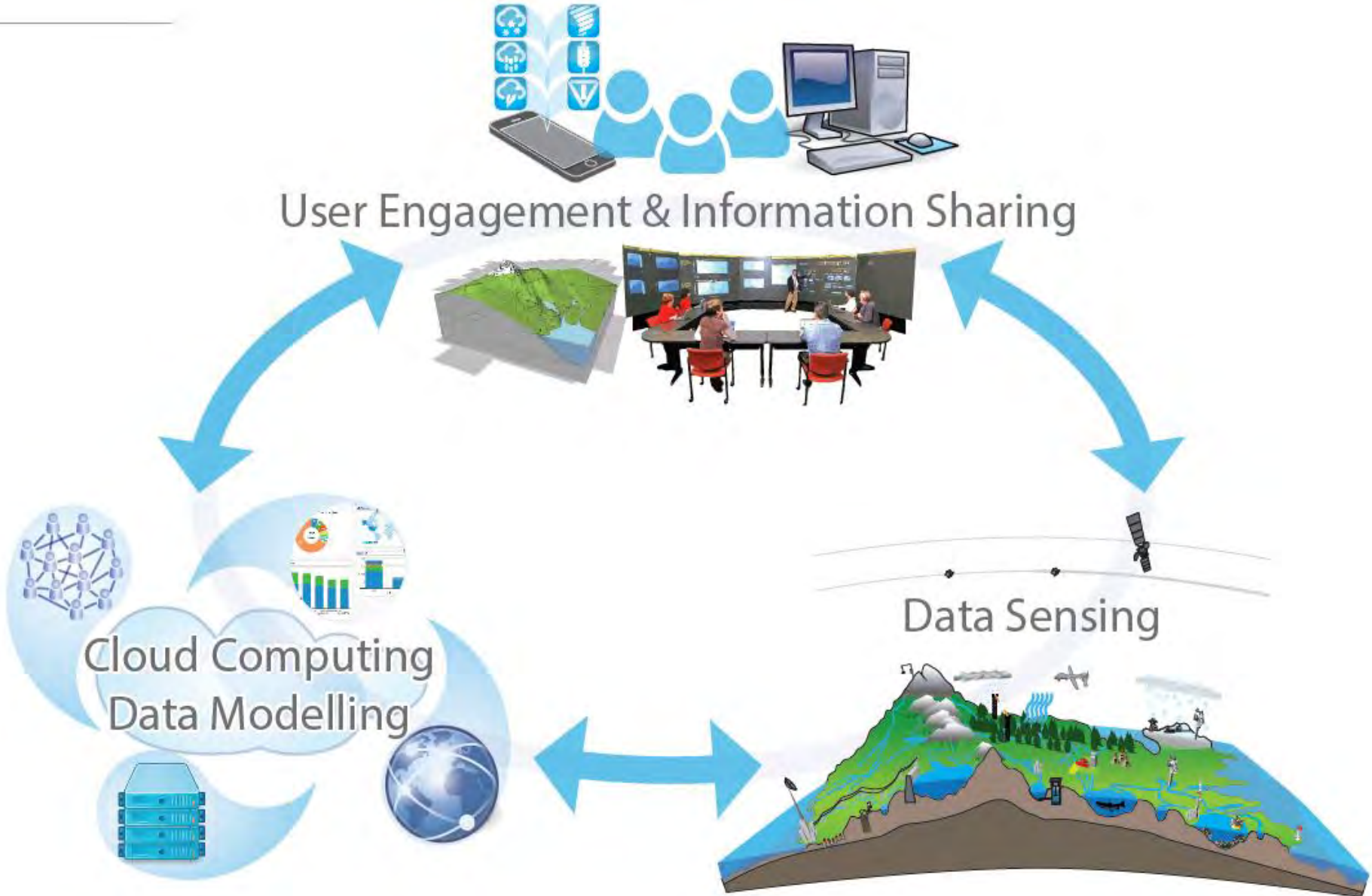
- **Improve disaster warning** – develop scientific knowledge, monitoring and modelling technologies, and national forecasting capacity to predict the risk and severity of extreme events
- **Predict water futures** – use Big Data to make informed decisions, better models to assess change in human/natural land and water systems
- **Inform adaptation to change and risk management** – propose governance mechanisms, management strategies, and policy tools to reduce the risk of water threats, design adaptive strategies, and enhance economic opportunities

Transdisciplinary Science Pillars

- **Pillar 1** - Diagnosing and Predicting Change in Cold Regions
- **Pillar 2** - Developing Big Data and Decision Support Systems
- **Pillar 3** - Designing User Solutions



Big Data for Canada's Water



Pillar 3 – Designing User Solutions

- Provide tools and solutions that Canada and similar cold regions currently lack to manage the water environment in the face of unprecedented change
- Develop the data access, models and new visualization and interactive decision-making systems to predict and manage risk
- Launch a new era of public water warning and information through apps and social media
- Open a new era of water-related public engagement, drawing on social media with apps that engage and inform the public, crowd-source data and provide place-based real-time information

Global Water Futures: Pillar-3 Projects
(effective 1 June 2017)

- 12 Projects
- 15 Universities
- 117 PIs &Co-Is
- 135 Partners
- Training 257 HQP over 3 years

- $16.9 million GWF grant funding
- $26.4 million cash support
- $116.5 million in-kind support

GWF Pillar-3 Projects & PIs

- Climate-Related Precipitation Extremes, **Ronald Stewart**, University of Manitoba; **Francis Zwiers**, University of Victoria
- Northern Water Futures, **Jennifer Baltzer** and **William Quinton**, Wilfrid Laurier University
- Next Generation Solutions to Ensure Healthy Water Resources for Future Generations, **John Giesy**, University of Saskatchewan
- Forecasting Tools and Mitigation Options for Diverse Bloom-Affected Lakes, **Helen Baulch**, University of Saskatchewan
- Agricultural Water Futures in Canada: Stressors and Solutions, **Merrin Macrae**, University of Waterloo
- Canada's Boreal Wildlands-Society-Water Nexus, **Mike Waddington**, McMaster University

GWF Pillar-3 Projects

- Prairie WATERSAVE: Sustainable Water Management for Civic and Provincial Policy Makers and Urban, Rural, and Indigenous Communities, **Jeff McDonnell** (**Chris Spence)**, University of Saskatchewan
- Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins, **Saman Razavi**, University of Saskatchewan
- Mountain Water Futures, **Sean Carey**, McMaster University
- Lake Futures – Enhancing Adaptive Capacity and Resilience of Lakes and their Watersheds, **Nandita Basu**, University of Waterloo
- Transformative Technologies for Canadian Water Futures – Big Data Platform and "Smart" Watersheds, **Claude Duguay**, University of Waterloo
- Co-creating of Indigenous Water Quality Tools, **Dawn Martin-Hill**, McMaster University

Core Support Teams

- Knowledge Mobilization – UofS-Steelman, WLU-Blay-Palmer, UW-Kevin Boehmer (UofS-RS-1, UW-RS-1, WLU-RS-1)
- Computer Science – UofS-Schneider, UW-Lin (UofS-RS-2, UW-RS-1)
- Data Management – UofS-Pomeroy, McM-Carey, WLU-Baltzer, UW-Lin (UofS-Tech-1, McM-Tech-1, WLU-Tech-1)
- Research Technicians
  - UofS – 6 (Airborne Cold Regions Observatory, Water Isotope Ecohydrology Laboratory, Boreal Forest and Prairies – 2, Canadian Rockies Hydrological Observatory – 2)
  - UW – 5 (Remote Sensing, Smart Sensors Network, Water Quality and Aquatic Ecosystem, Smart Watershed – 2)
  - WLU – 5 (Ecosystem Resilience, Hydrometeorological, Permafrost, Water Quality, Biomonitoring)
  - McM – 4 (Yukon Research Sites – 2, Northern Boreal Plains, Ontario Observatories)

GWF Integration of National Water Modelling & Observation Strategies

- **Core support teams to deliver national modelling capability, new observational science and knowledge mobilization**

- **User focussed research questions**
  - **How will the hydro-climatic conditions of Canadian watersheds change in response to global climate change and changes to the environment, particularly to new extremes?**

  - **What will be the future of water quality in response to hydro-climatic changes, agricultural activities, industrial developments, land use change, and water management?**

  - **How can basin-wide water management and decision making process be improved under the new hydro-climatic and water quality conditions, where there are vast social, economic, and environmental issues?**

National Hydrology Research Centre, Saskatoon

Canadian Centre for Water Forecasting and Prediction, Saskatoon

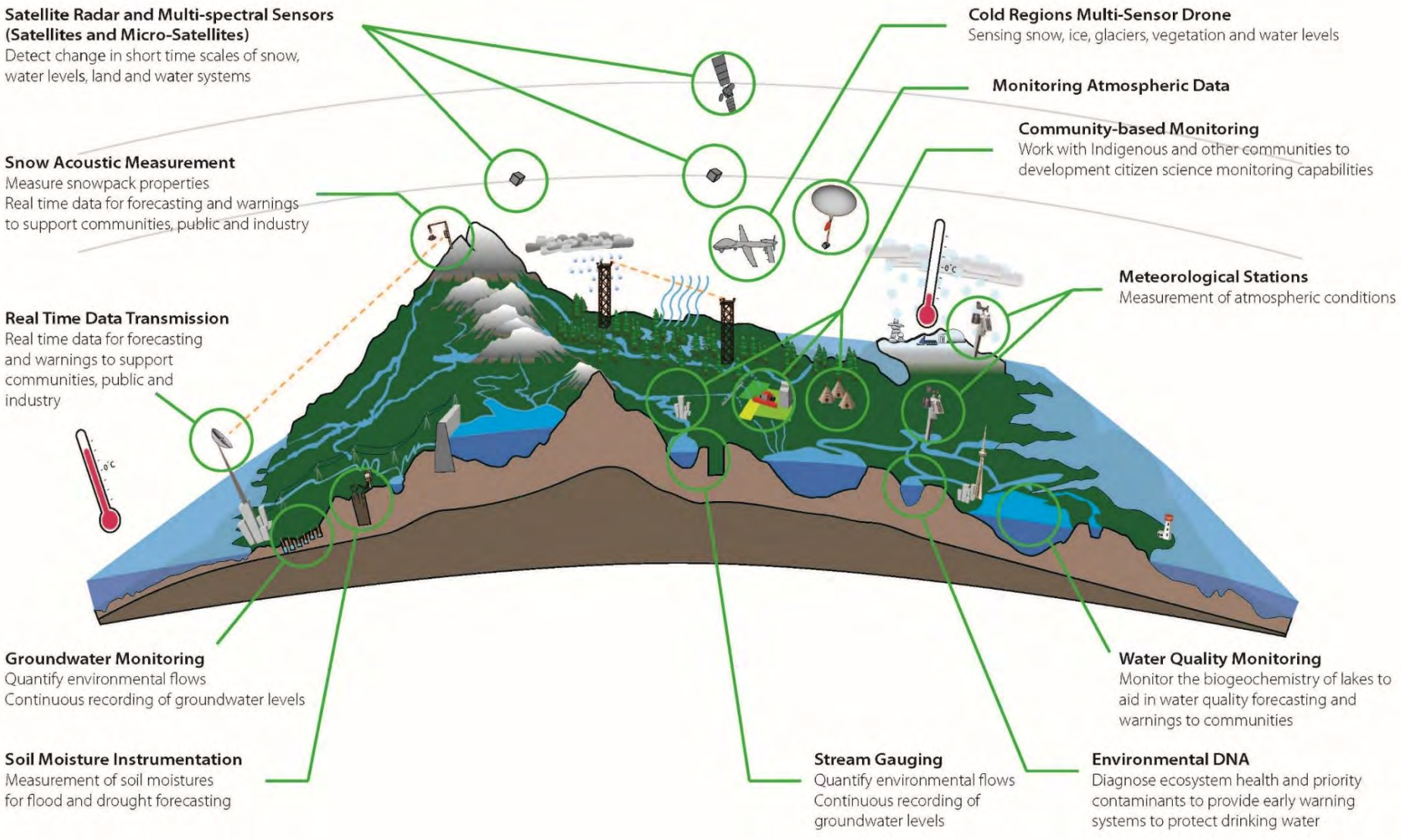
Coldwater Laboratory, Canmore, Alberta

Novel Water Measurements

Canadian Rockies Hydrological Observatory

Drone based remote sensing

A revolution in observing change



Multiscale Comprehensive Modelling Approach

- Fine scale hydrological, water quality, atmospheric, cryospheric, fire and crop models – mountains, agriculture, forests
- Large scale hydrological modelling coupled to atmospheric models – core of a national water prediction and forecasting system
- Large scale water quality modelling driven by hydrological models and feeding to water management and decision support models
- Decision analysis and support system
  - Water resources modelling
  - Shared vision model
  - Decision optimization model

GWF National Modelling Strategy

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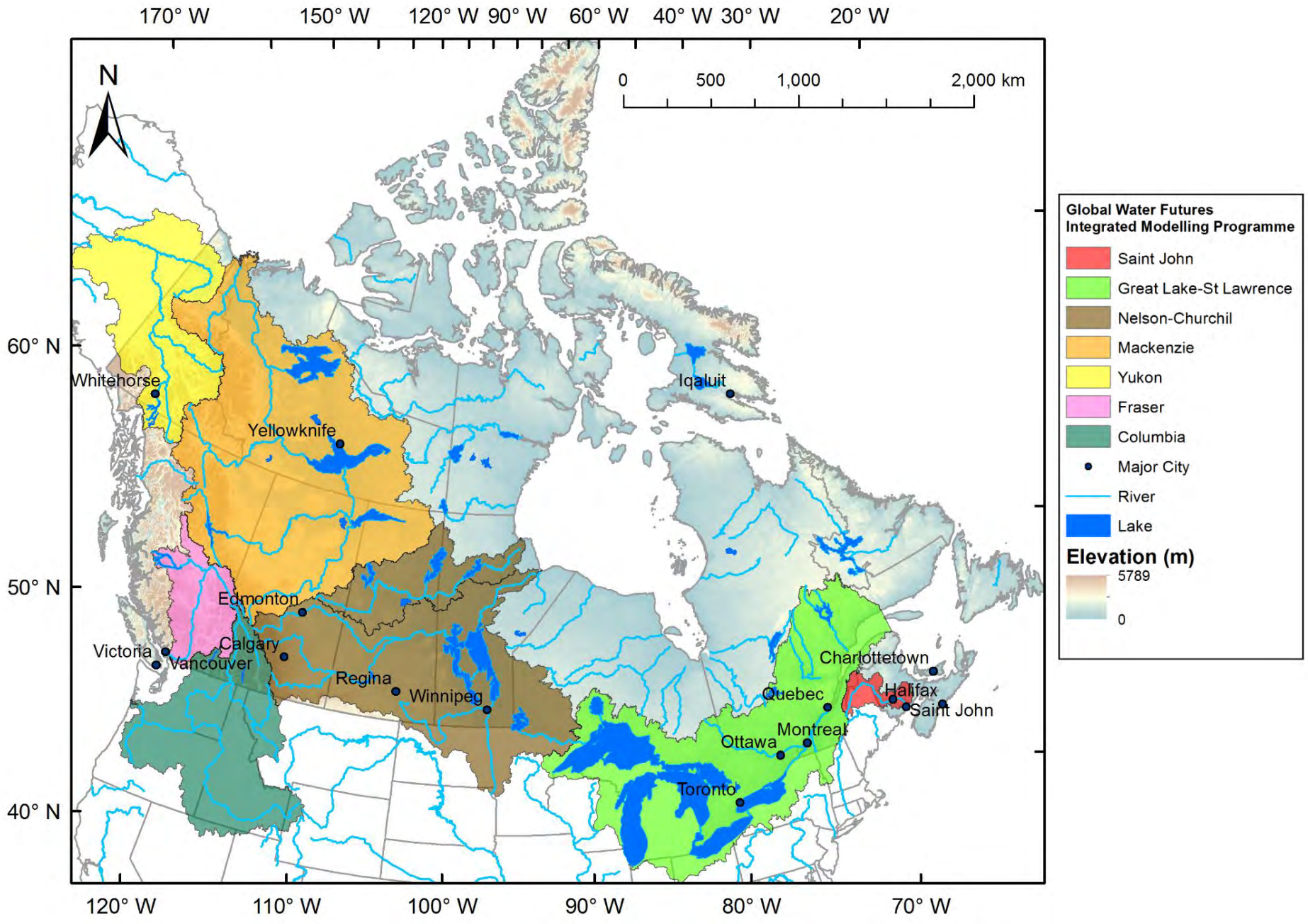


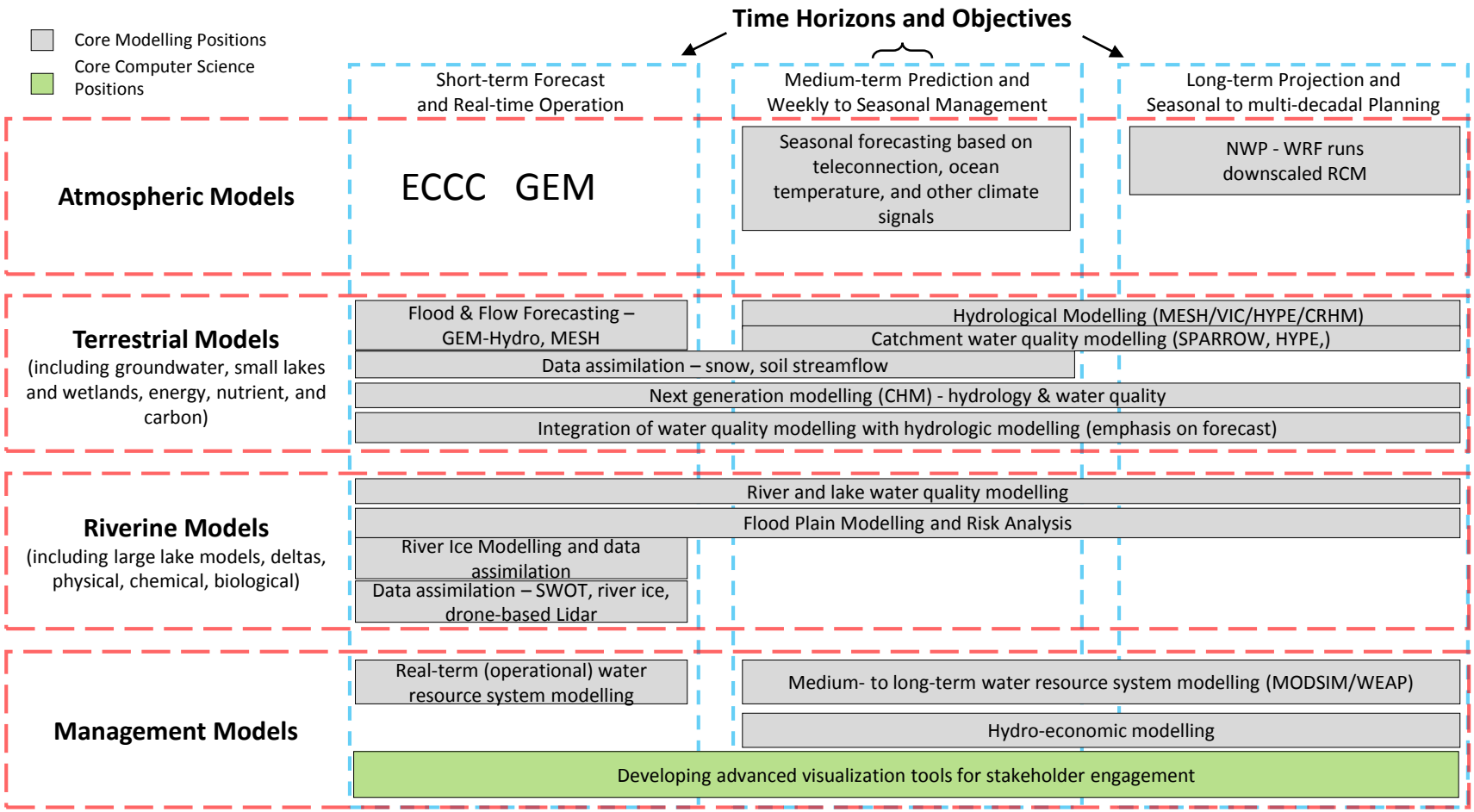
Core Team – Modelling & Forecasting

- Hydrological and Water Quality Development
  - **Flood Forecasting** (UofS-RS-2*)
  - **Seasonal and Drought Forecasting** (UofS-PDF-1)
  - **Floodplains** (McM-PDF-1)
  - **Data Assimilation** (UofS-PDF-1, UofS-Eng-1*, UW-PDF-1)
  - **River Ice Modelling** (UofS-PDF-1)
  - **Water Quality** (UofS-PDF-1, UW-PDF-1)
- Climate Change and Diagnostic Applications
  - **Climate - high resolution pan-Canadian** (UofS=RS-1, UofS-PDF-2*, UofS-GS-1)
  - **Hydrological Modelling** (UofS-RS-1, UofS-PDF-2*, UW-PDF-1)
  - **Next Generation Modelling** (UofS-RS-1, UofS-PDF-1, UofS-RO-2*)
  - **Catchment, River and Lake Water Quality** (UofS-RS-1, UofS-PDF-1, UW-RS-1, UW-PDF-1, McM-PDF-1)
- Water Resources Systems
  - **Water Resources** (UofS-RS-1, UofS-PDF-1, UW-PDF-1)

*denotes UofS supplemental funding

currently a team of 30

GWF National Integrated Modelling Strategy



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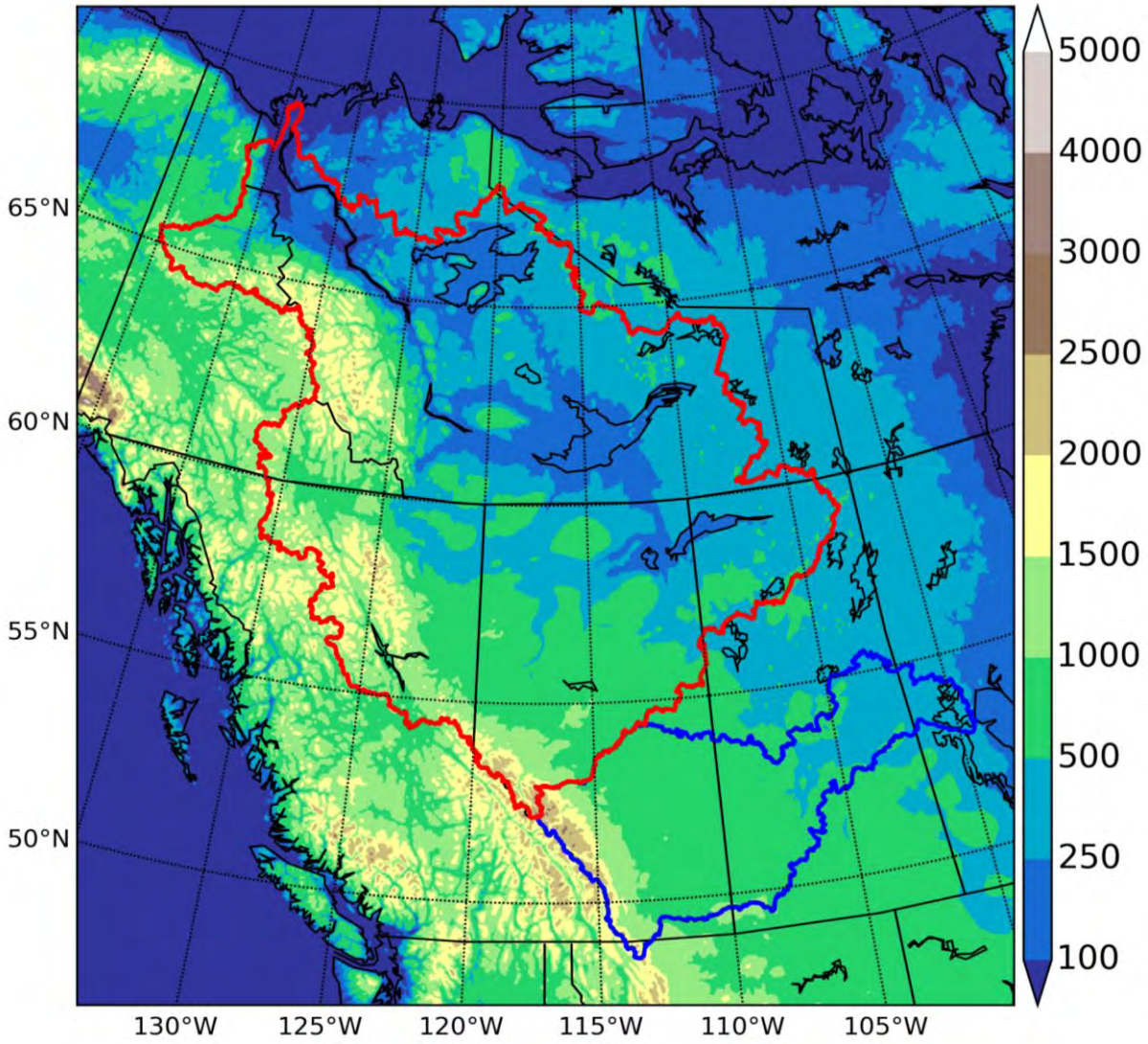
Website: www.globalwaterfutures.ca

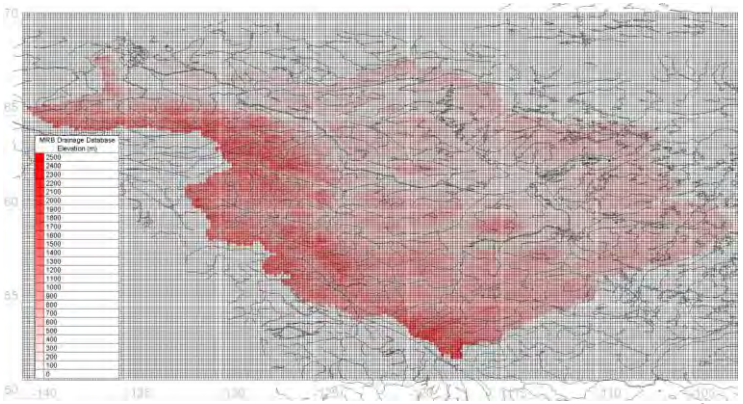
Large Scale Modelling

- Regional Climate Simulation using 4-KM WRF



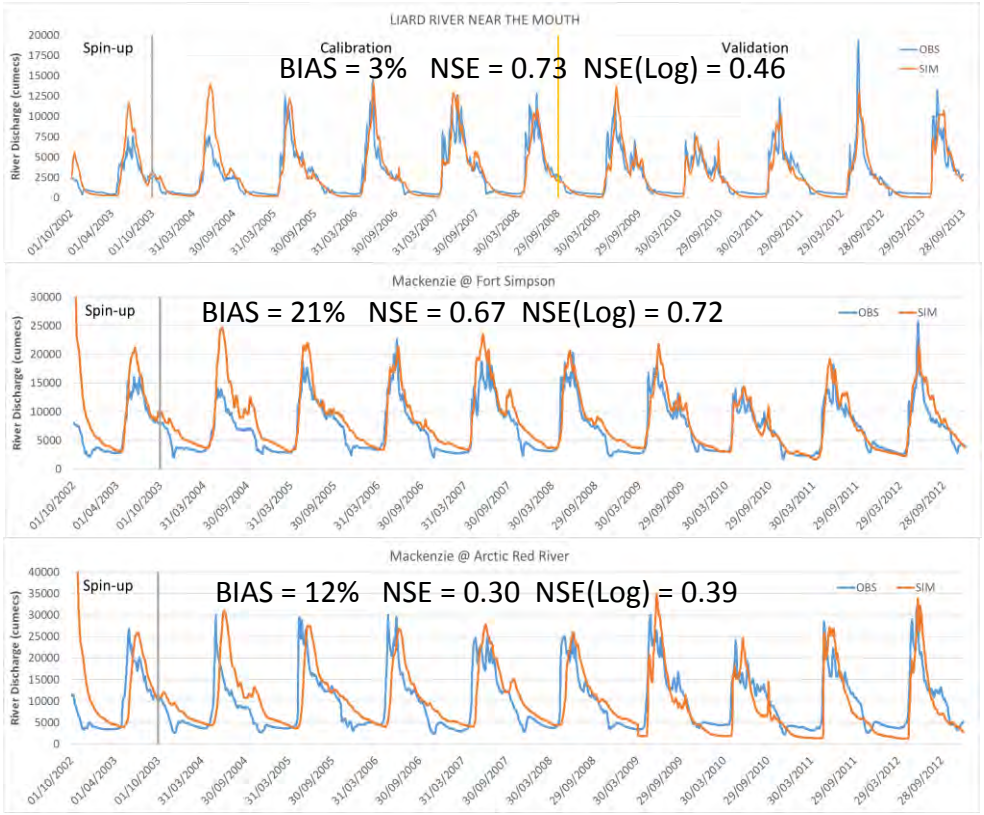
Large Scale Modelling

- Modelling the hydrology of the Mackenzie River Basin



19,598 grid cells, 8 GRUs, 1.755 M km^2

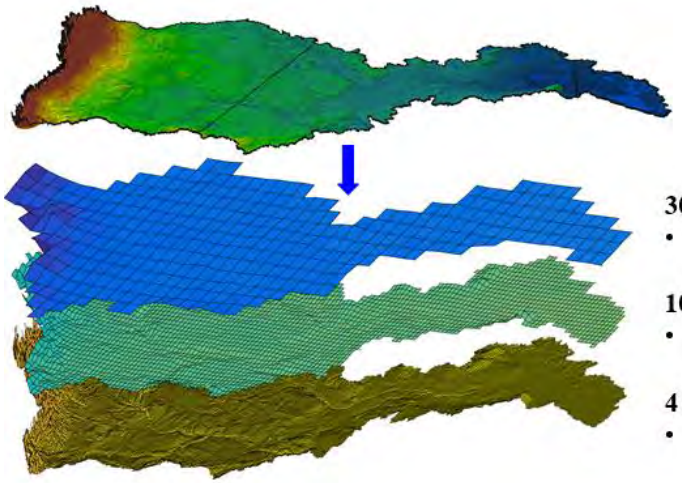
- Large lakes important and require proper attention
- Calibration from sub-basins generalized to the larger basin—two distinct regions (E and W portions of the basin)
- Representation of permafrost poses ongoing challenge



Model discharge results for Liard and Mackenzie Rivers

Large Scale Modelling

- Modelling the hydrology of the Saskatchewan River Basin

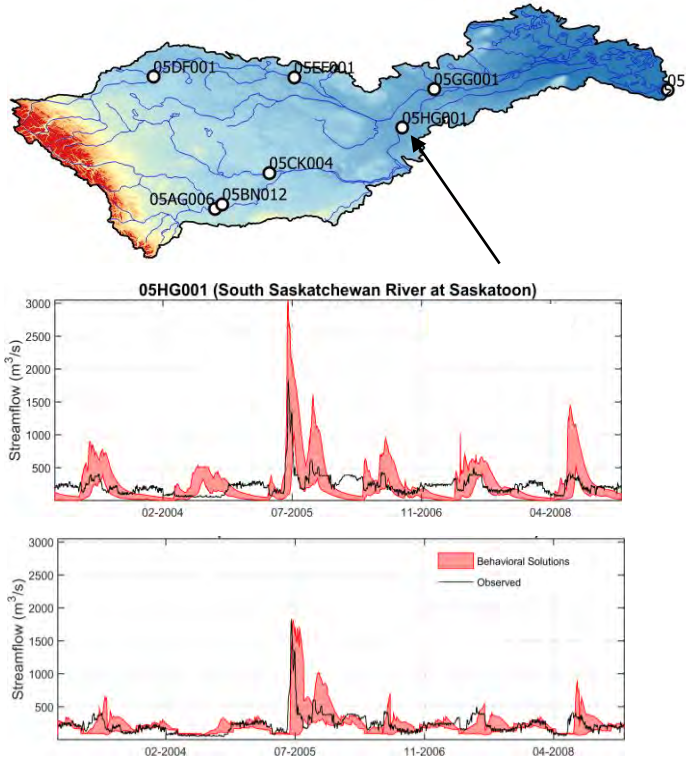


30 Km grid resolution
- 457 grid cells

10 Km grid resolution
- 3653 grid cells

4 Km grid resolution
- 42,178 grid cells

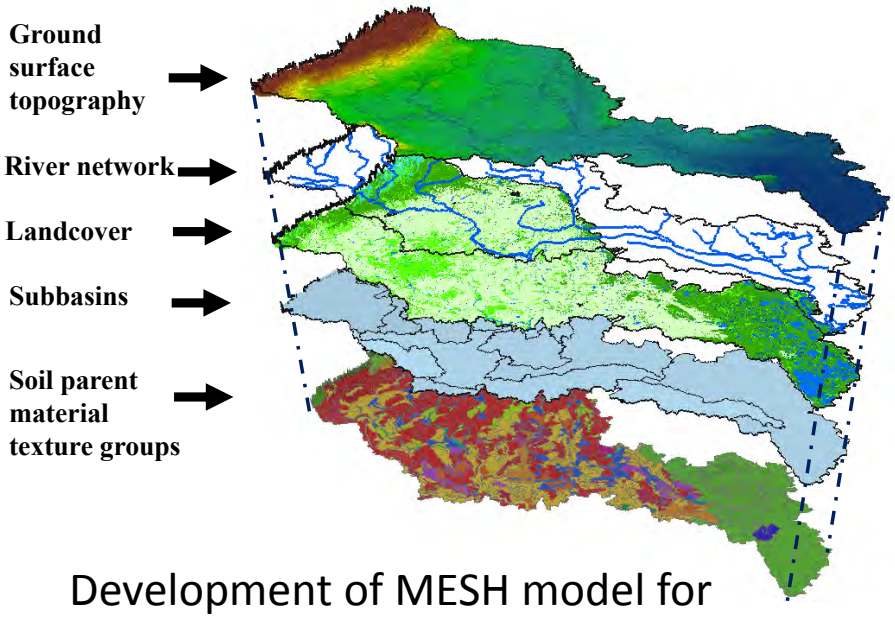
MESH model setup and evaluation for Sask. R. Basin at multiple resolutions; multi-objective calibration includes water balance constraints



Human water use (dams, irrigation) is a key determinant of the hydrograph

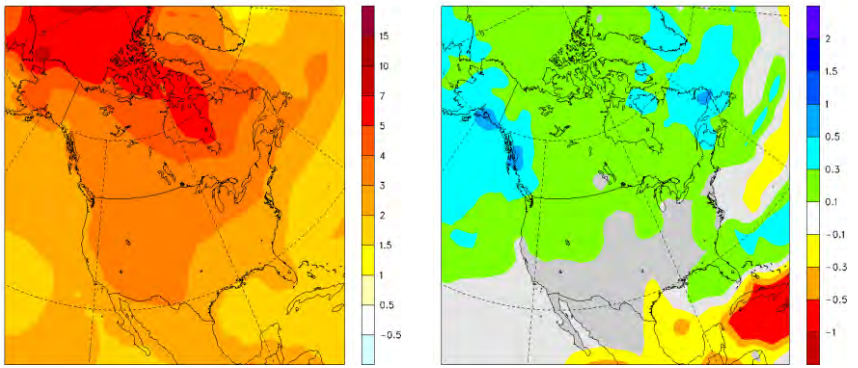
Future Change in the 21st Century

- Large-scale models will be used to assess land and water futures
- Requires development of scenarios of landcover change

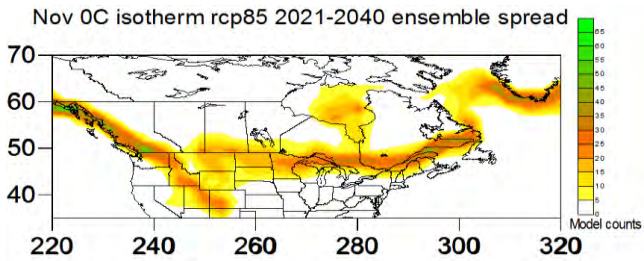


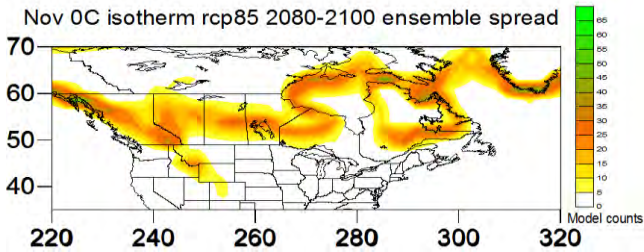
Development of MESH model for Saskatchewan River Basin

Canadian model projected conditions
RCP8.5 '2050' – (1986-2005)



November positioning of 0°C in RCP8.5 projections



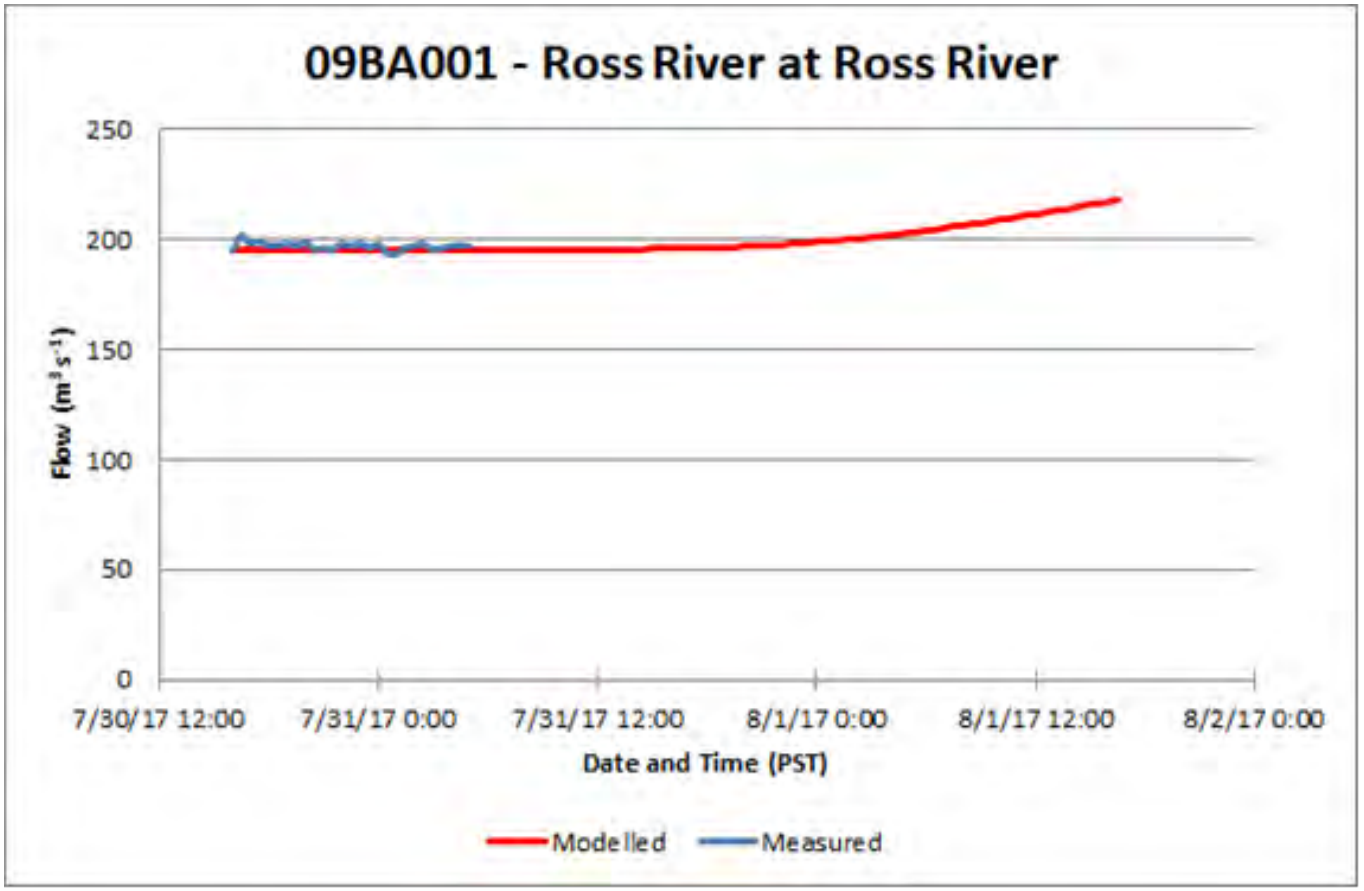


Addressing User-led Questions on Extremes

- Can droughts and floods be predicted with less uncertainty and longer lead-times?
- Will droughts increase in frequency, severity and extent?
- Will floods increase or decrease in peak flow and will timing change
- Can water resources management better mitigate the impacts of flooding and drought?

- **Development of a *National Flood and Drought Forecasting System***
  - ***Initially GEM-Hydro and MESH-based, later including a new multiphysics modelling system***

GEM-MESH Operational Forecasts

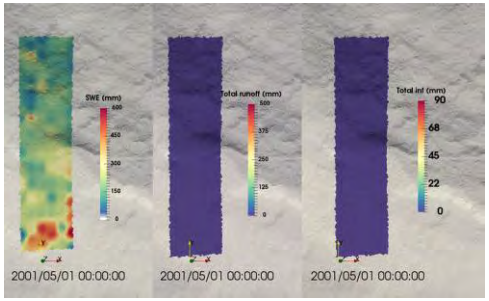


Canadian Hydrological Model (CHM)

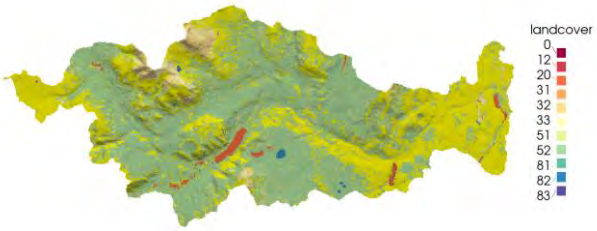
- Need to understand complex hydrological changes in cold regions
- Traditional modelling approaches are less viable under anthropogenic changes
- Next generation forecast and diagnosis hydrological model

Example model outputs

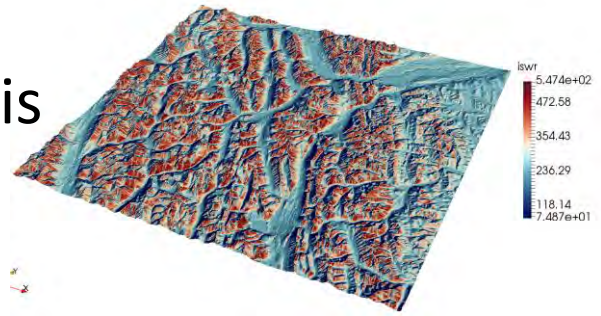
Hillslope (1 km^2)



Basin (100 km^2)



Regional (8000 km^2)



Provincial (500 000 km^2)