Global Water Futures Programme and its Science Contributions to GEWEX

John Pomeroy,
Director, Global Water Futures Program
Centre for Hydrology, University of Saskatchewan, Saskatoon & Canmore

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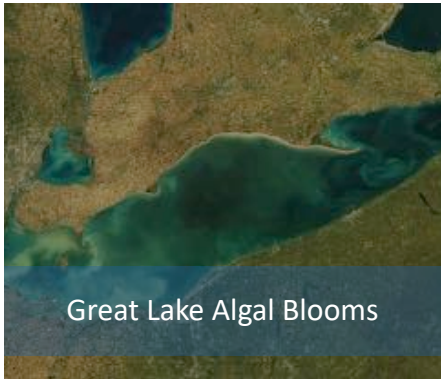
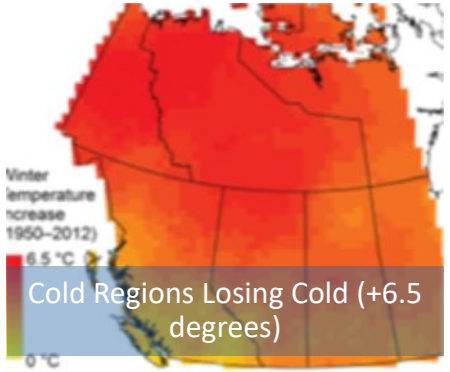
Our water is increasingly at risk


Toronto Flood (2013)


Great Lake Algal Blooms


Drought



Cold Regions Losing Cold (+6.5 degrees)


Permafrost Thaw


Unprecedented Prairie Summer Flooding


Extreme Wildfires


Yukon's Slims River Changes Flow Direction

Climate Change

Urban and Industrial Development

Agricultural Intensification

Global Water Futures: Solutions to Water Threats in an Era of Global Change

GWF aims:

a) to **place Canada as a global leader in water science for cold regions**,

b) to **address the strategic needs of the Canadian economy** in adapting to change and managing the risks of uncertain water futures and extreme events.

Global Water Futures - Mission

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

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

GWF Today

- $77.8 million grant from *Canada First Research Excellence Fund* 2016-2023
- GWF has funded 33 Projects
  - 15 universities across Canada
  - 152 university faculty investigators
  - 481 Researchers hired over the first three years
    - graduate students, post-doctoral fellows, scientists, engineers, technicians, and managers
  - 210 partners -- federal & provincial government agencies, First Nations, industry groups, international institutions, NGOs, and communities
- GWF supports three global programmes
  - UNESCO, World Climate Research Programme, Future Earth
- $185 million in GWF project and core team funding for first three years
  - $ 23.5M GWF cash grant awarded to projects
  - $ 14.6 M GWF funding to operate core teams
  - $26.8M leveraged by projects (cash)
  - $119.7M leveraged (in-kind support)

The Details

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- 21 transformative research, big data and decision support tool projects approved for Pillars 1 & 2
  - Atmospheric Science, Hydrology, Water Quality, Water Management & Governance, Health
  - Sensors, crowdsourcing, computing
- 12 user-question led projects funded for Pillar 3
  - Regional – e.g. Great Lakes, North, Prairies, Mountains, Boreal
  - Sectoral – e.g. Agriculture, Mining
  - Topical – e.g. First Nations co-development, modelling & prediction, algae, climate extremes
- 6 Core Teams Established
  - 36 core modellers
  - 7 computer scientists
  - 20 observatory technicians (Yukon, NWT, Rockies, Saskatchewan, Ontario)
  - 4 data managers
  - 4 knowledge mobilisation specialists including First Nation member specialist
  - 9 communications specialists
- Observatories Staffed, Predictions Started
  - $90M in federal budget for National Hydrological Service for enhanced water observations and national water prediction system – .
  - Flood forecasting system implemented for Yukon Territory
  - Mountain snow forecasting system for Bow River headwaters in Canadian Rockies
  - Mackenzie, Saskatchewan river basins modelled for current and future climates
  - Smart Water Systems Laboratory (Western Economic Diversification, CFI)

GWF "International"

- INARCH – mountain hydrometeorology and hydrology
- GEWEX –
  - applying as a Regional Hydroclimate Project
  - Water for the Food Baskets of the World
- UN Water Action Decade
  - Work with UN University
  - Strategy and Action Plan - Outreach
- Future Earth – Water Futures
- MESH Modelling – Iran, India, Israel
- Third Pole Environment Exchanges – Chinese Academy of Sciences
- Interest
  - Upper Nile, Indus, Andes, Kazahkstan

4th INARCH Workshop

Where: Hotel Portillo, Chile.
32.8ºS, 70.1ºW
2,880 m a.s.l.

When: Oct 24-26, 2018

GWF Inception Statement

- GWF has identified a *Grand Challenge*: **how can we best prepare for and manage water futures in the face of dramatically increasing risks from a changing climate, developing economy and changing society**?
- GWF is engaging with all levels of government across Canada, with special interest in engagement with Indigenous communities and international UN-based science organisations.

Climate Related Precipitation Extremes

Future occurrence of:

- Drought
- Summer precipitation including hail
- Freezing rain, snow

Objectives

- Support planning for and adapting to the environmental, health and economic impacts of identified critical climate-related precipitation extremes
- Provide in-depth insights into climate and climate modelling issues

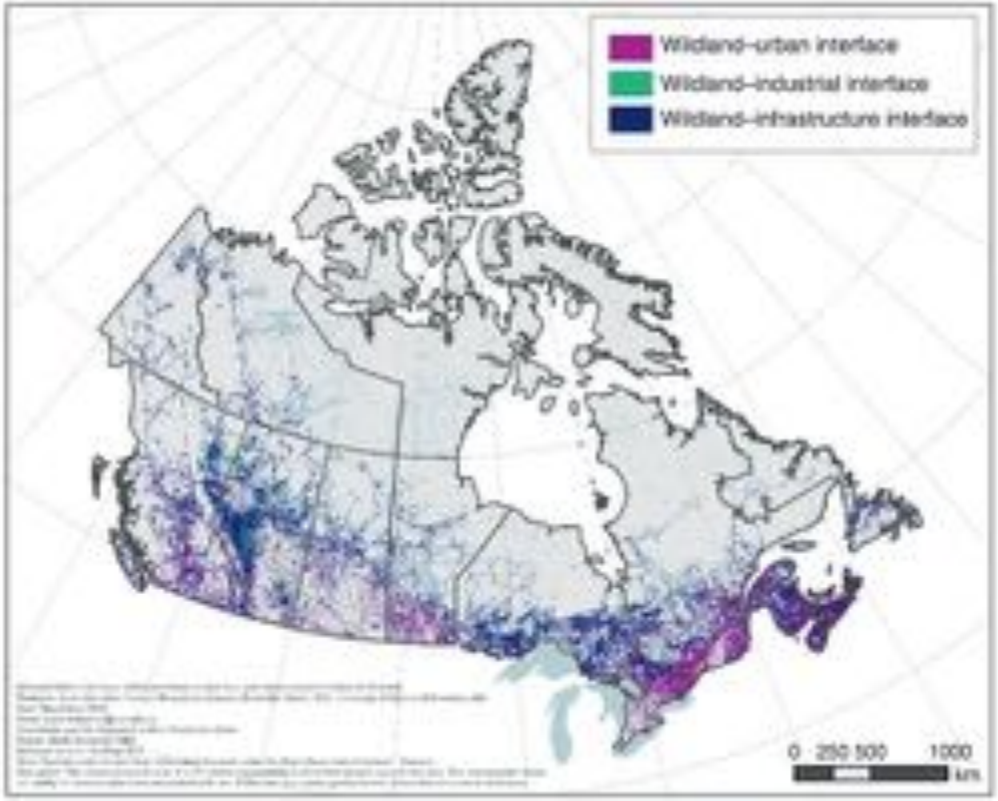
Agricultural Water Futures

- Examine prairie specific future scenarios:
  - warm season crops moving westward
  - regional intensification of livestock feeding industry
  - Water quality
  - significant expansion of irrigation industry

BOREAL WATER FUTURES

To develop a water futures risk assessment frame-work to create a more resilient boreal wildland-society interface.

Urban interface
Industrial interface
Infrastructure interface

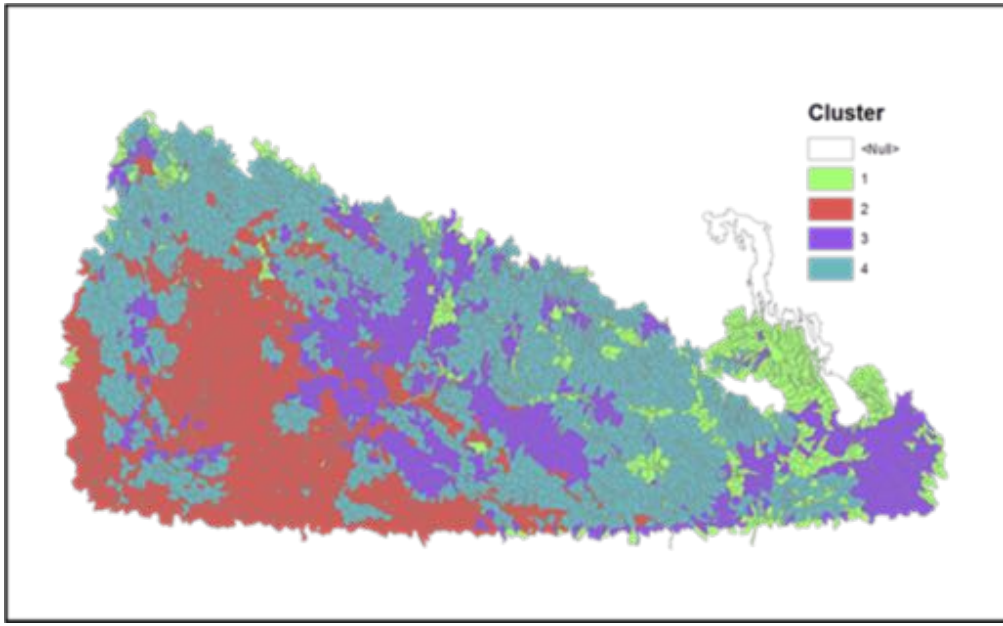


BWF
BOREAL WATER FUTURES
EST 2017

Prairie Water

- > 5.5 million people
- 80% of Canada's agricultural land (~$116 billion)
- Intensive land use

- Significant management and governance challenges:
  - lake eutrophication
  - wetland drainage
  - water availability and quality
  - groundwater sustainability



Mountain Water Futures

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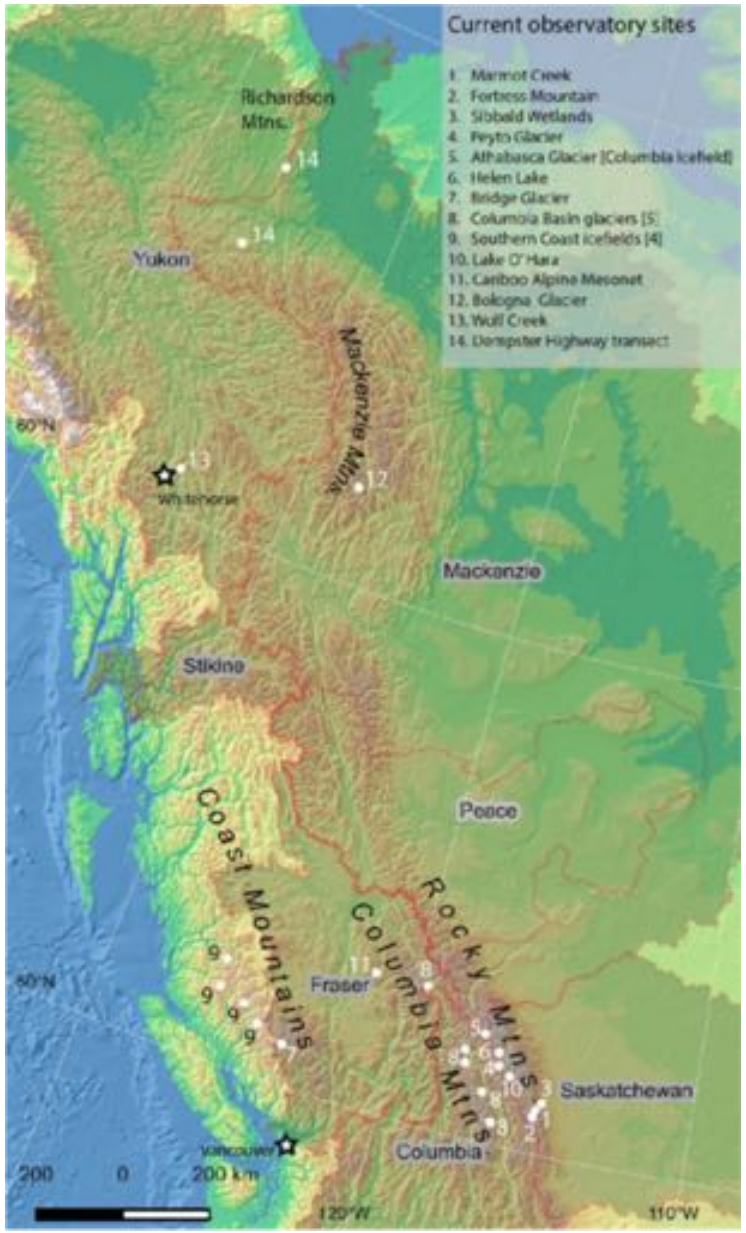
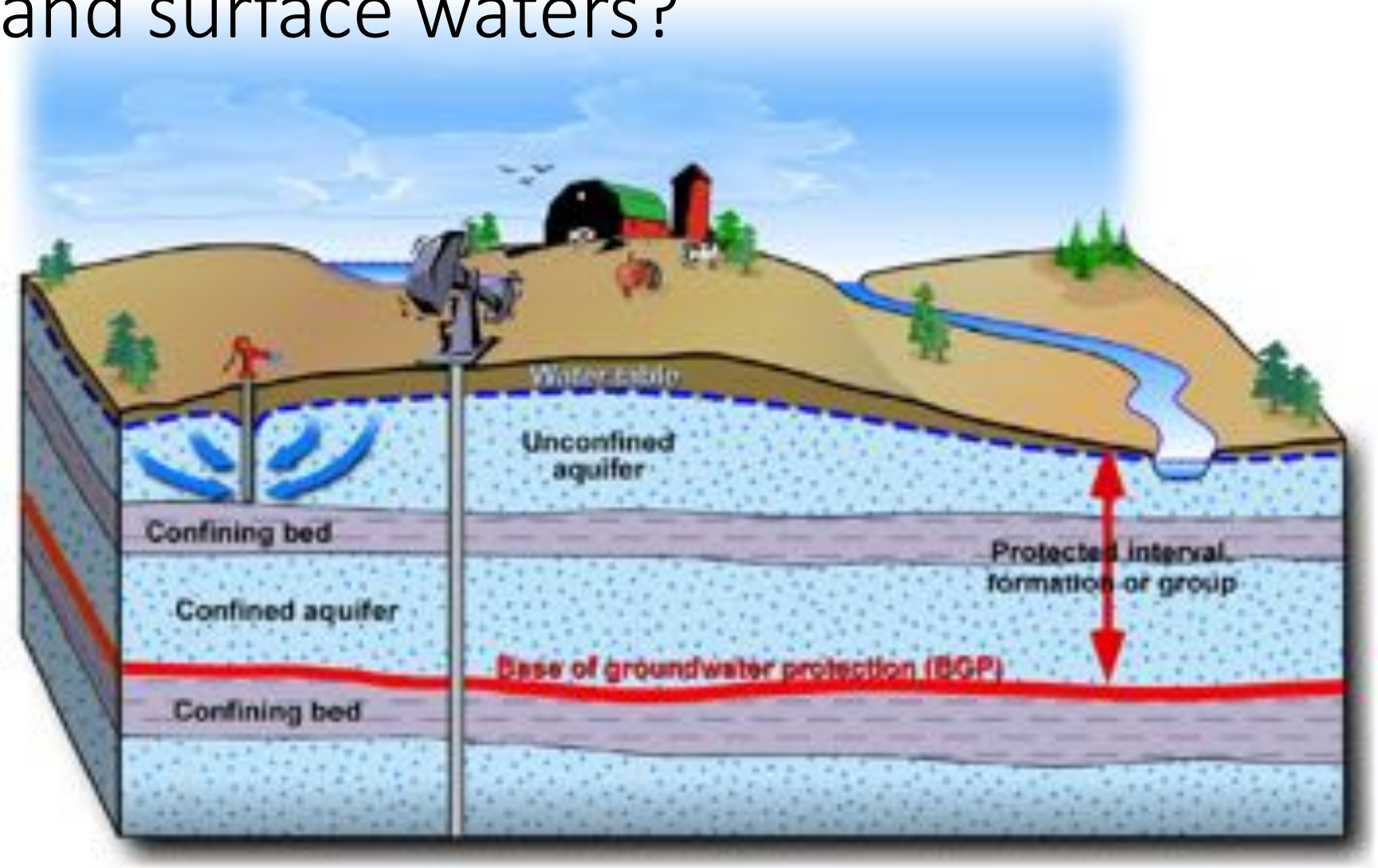


Old Meets New: Are deep hydrogeological systems separate from shallow aquifers and surface waters?



Integrated Modelling for Prediction and Management of Change in Canada's Major River Basins

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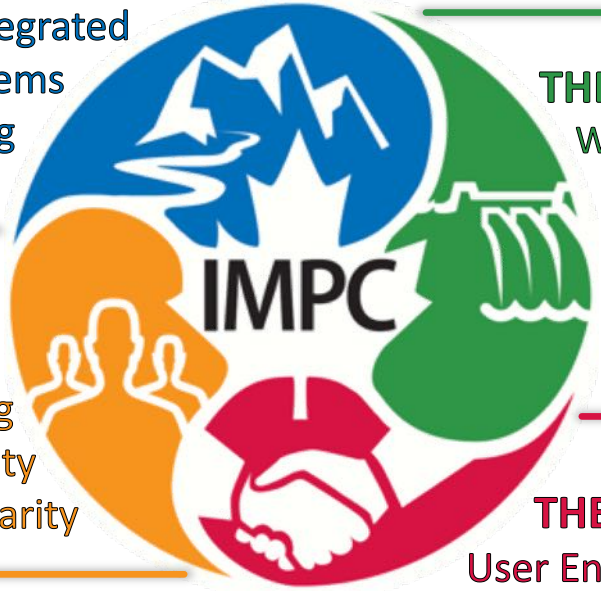
THEME A:
Integrated Earth Systems Modelling

- **A1:** Atmospheric Modelling
- **A2:** Hydrologic Modelling
- **A3:** Water Quality Modelling
- **A4:** River Ice Modelling
- **A5:** Model Intercomparison
- **A6:** Floodplain Mapping
- **A7:** Uncertainty Characterization

THEME B:
Water Management Modelling, Coupling Human-driven and Natural Systems

- **B1:** Basin-wide Water Resource Modelling
- **B2:** Environmental Demands
- **B3:** Hydro-economic Modelling



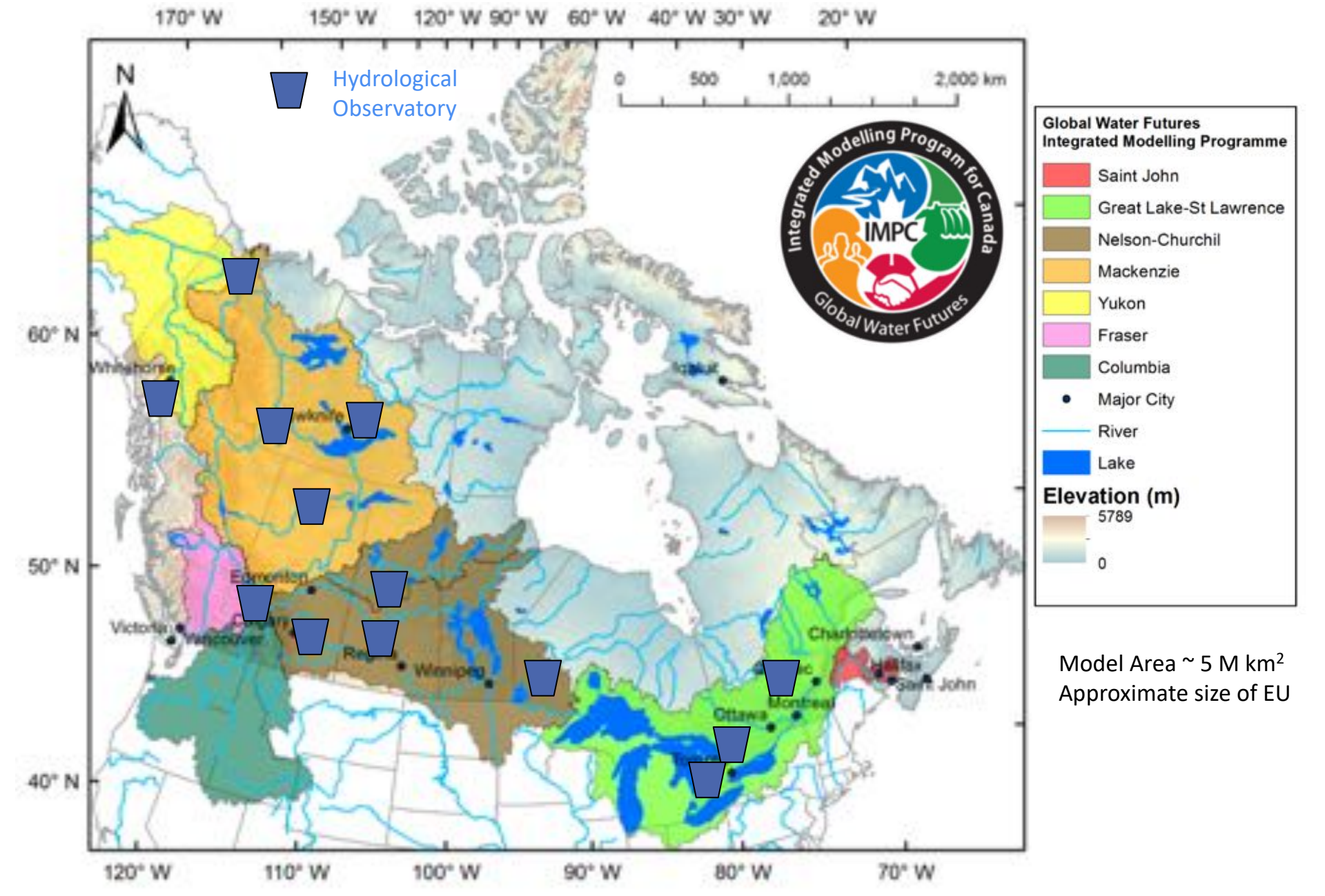
THEME C:
Decision Making under Uncertainty and Non-stationarity

- **C1:** Future Scenario Generation
- **C2:** Optimization and Multi-Criteria Decision Analysis

THEME D:
User Engagement and Knowledge Mobilization

- **D1:** Outreach and User Engagement
- **D2:** Decision Support Systems

GWF National Water Prediction Strategy



GWF National Water Observation and Prediction Strategy

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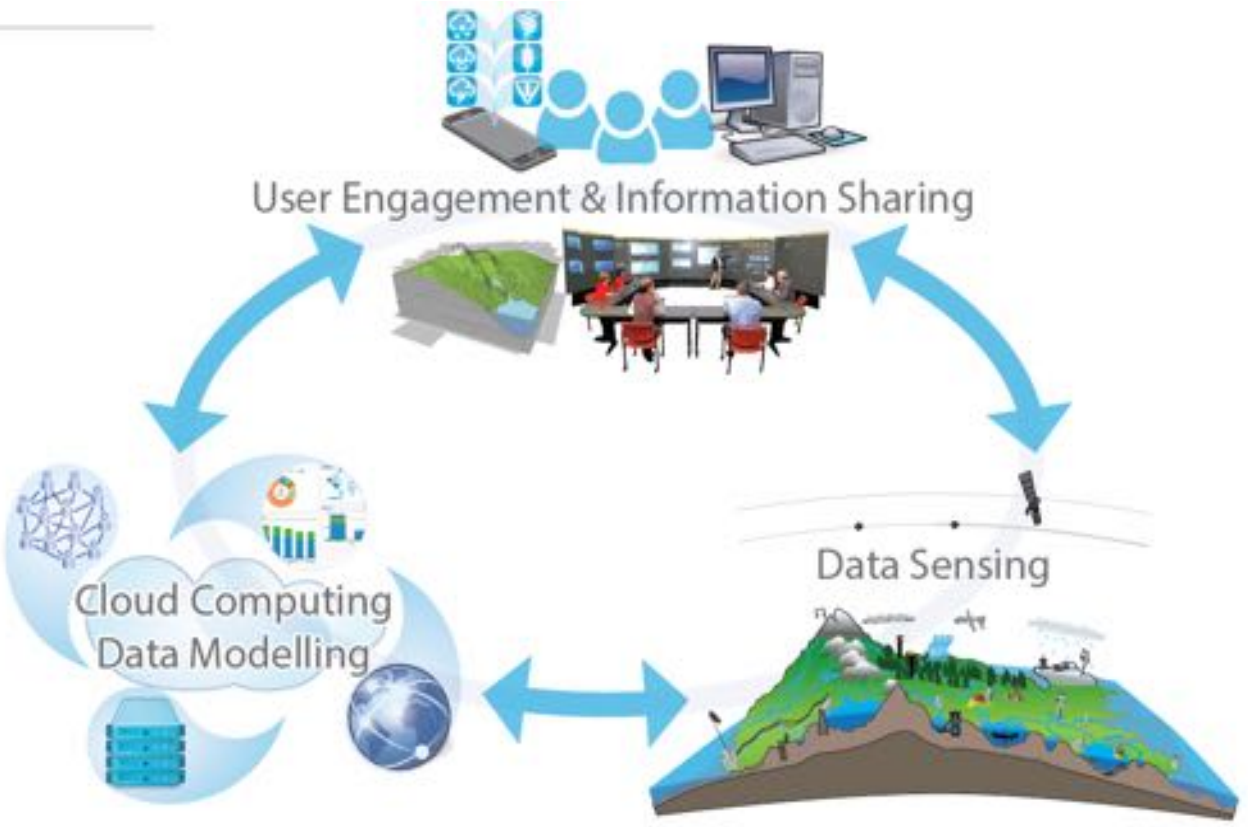
- **Core support teams to deliver national modelling capability, advanced computer science, new observational science and knowledge mobilization**
- **User-question led project-focussed funding**

- **Technical Team (20)**: Observatories & Observations
- **Data Management (4)**
- **Computer Science (7)** – Human Computer Interface, Data & Re-engineering Codes
- **Modelling Core Team (36)**
  - Hydrological & Water Quality Forecasting
  - Climate Change, Diagnostic Hydrological & Water Quality Modeling
  - Water Resources Modelling
- **Knowledge Mobilization (4)**
- **Communications (9)**



GWF Multi-modelling Strategy

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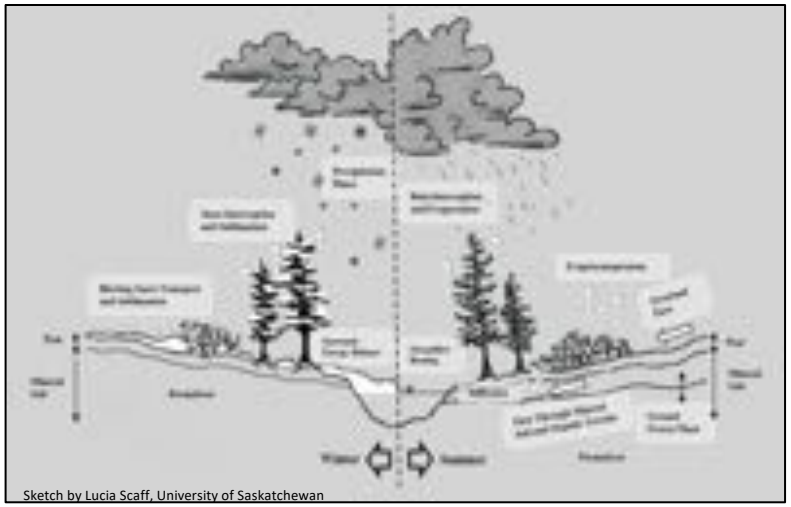
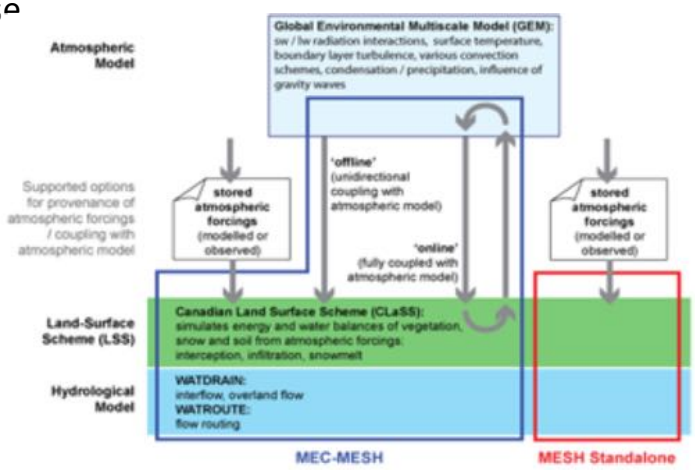
Cold Regions Hydrological Modelling Platform (CRHM)

-modular, flexible, object oriented process modelling
-users select modules to create a custom model
-spatial discretization based on hydrological response units
-catchment applications



*Pomeroy et al., 1998; 2007, 2016

-GEM-Hydro – with ECCC
-VIC
-HYPE
-Various water quality models

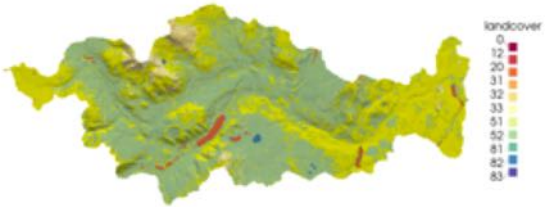


Pietroniro et al., 2007

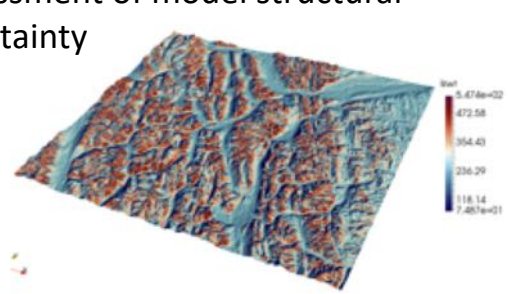
MESH -Coupled land surface hydrological model
-Feedback with atmospheric and groundwater models
-Water management
-Cold regions
-Flexible
-Large river basins

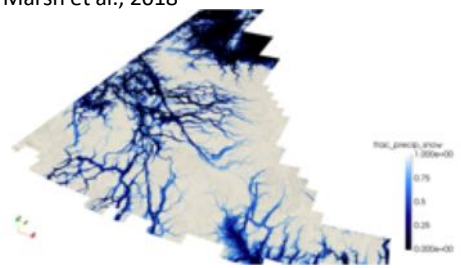
Canadian Hydrological Model (CHM)

Multi-scale, multi-physics, variable complexity and domain model
-Efficient TINS
-Assessment of model structural uncertainty



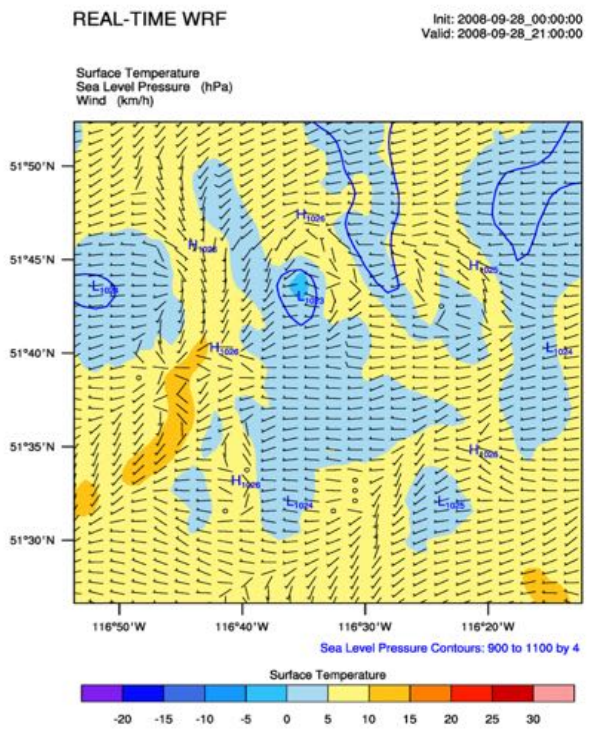
Marsh et al., 2018





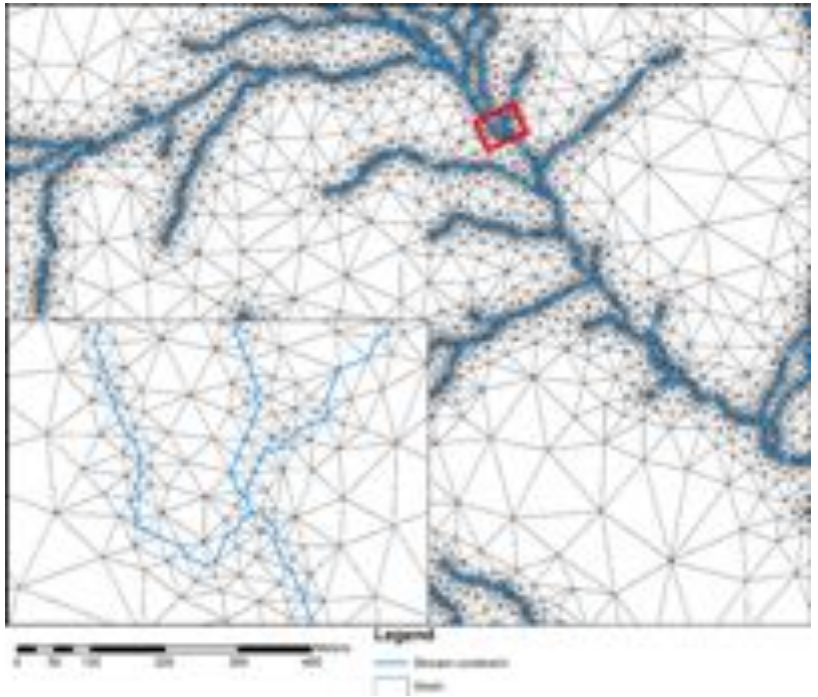
New High Resolution Modelling Approaches

High Resolution Atmospheric Models



Conway, Helgason, Pomeroy, 2018

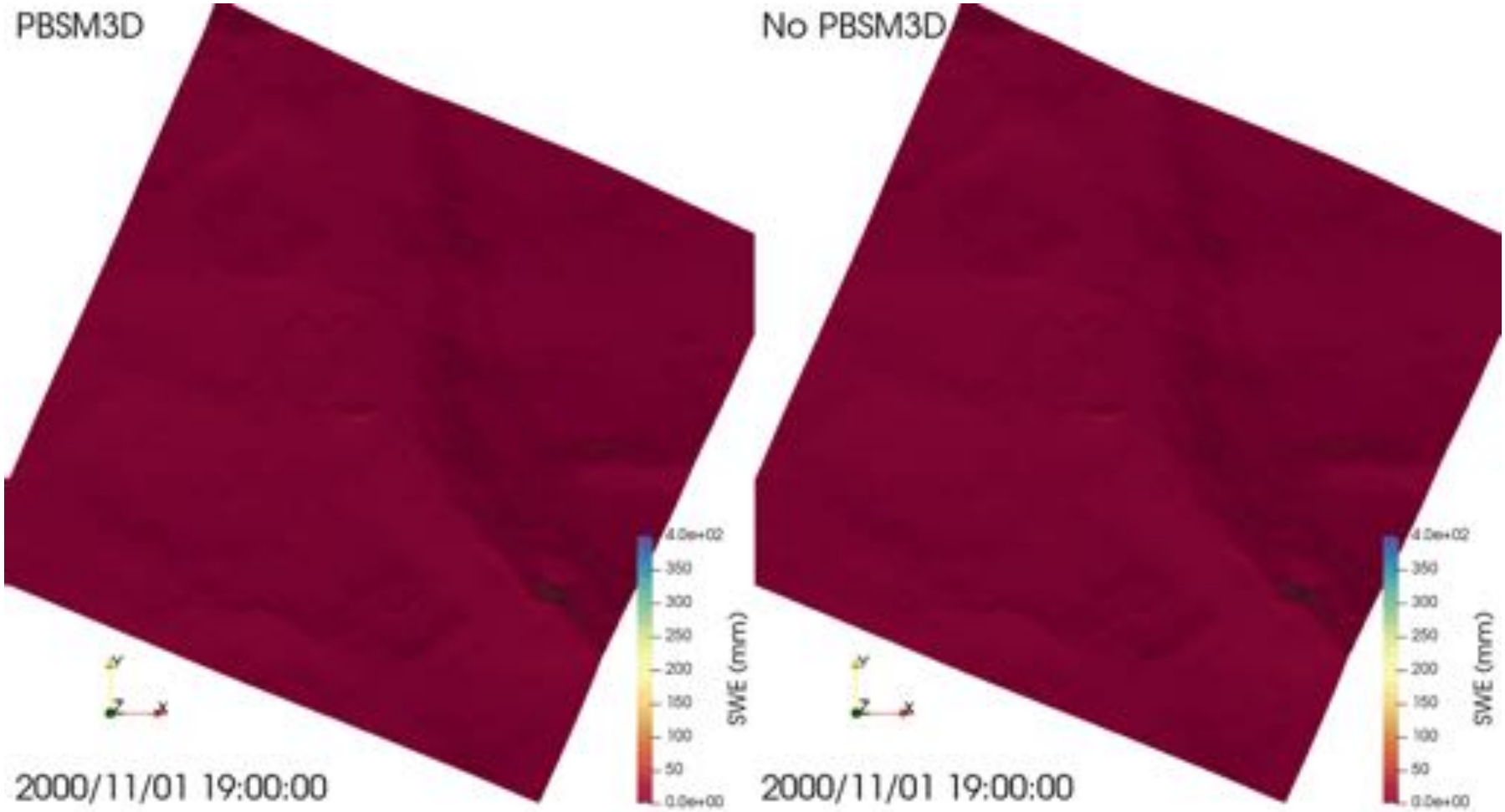
Variable Mesh, Physically Based, Multi-physics Hydrological Models



Coupling at hillslope-snowdrift scale

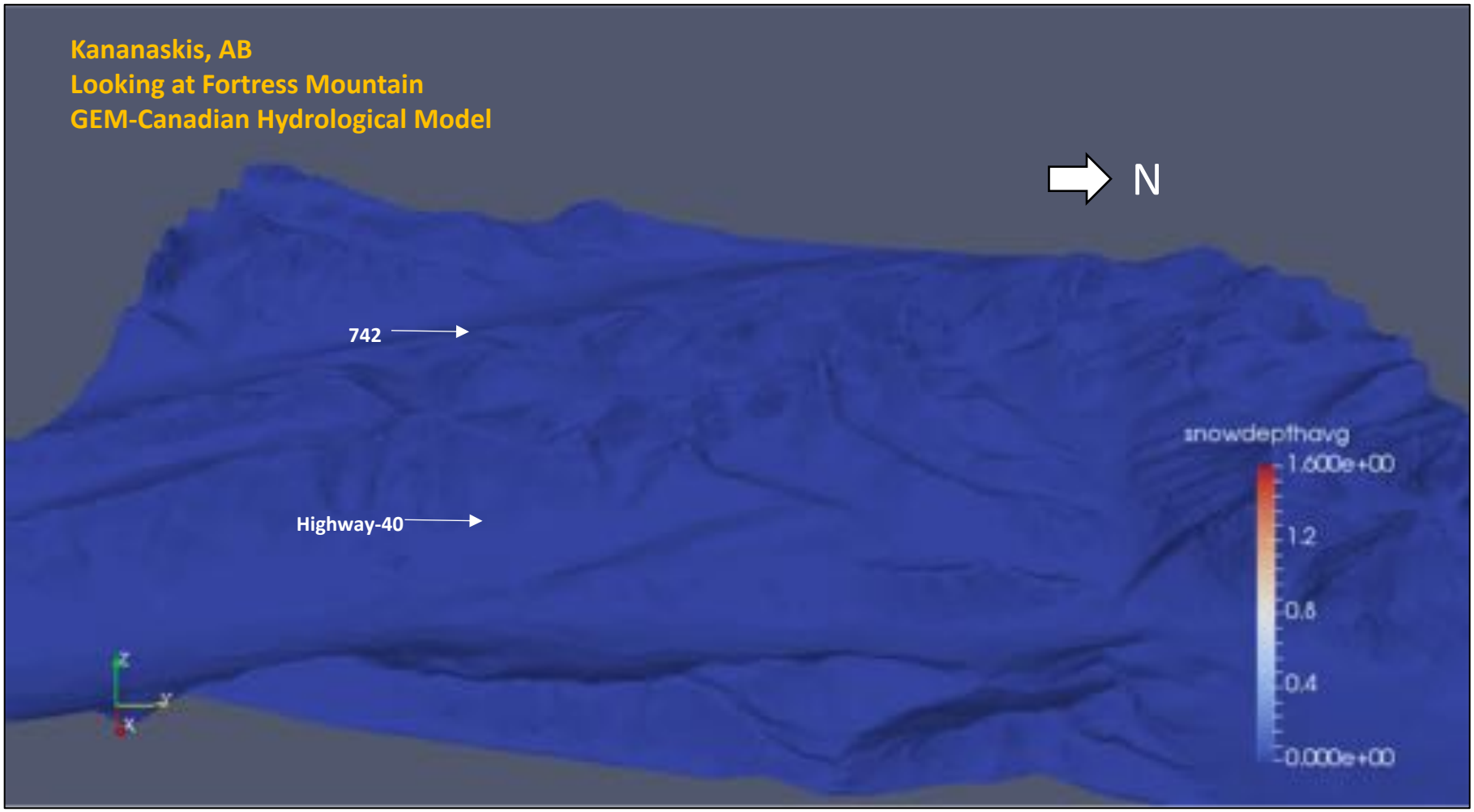
Marsh, Spiteri, Pomeroy, Wheater, 2018

Hydrology is Governed by Spatial Variability

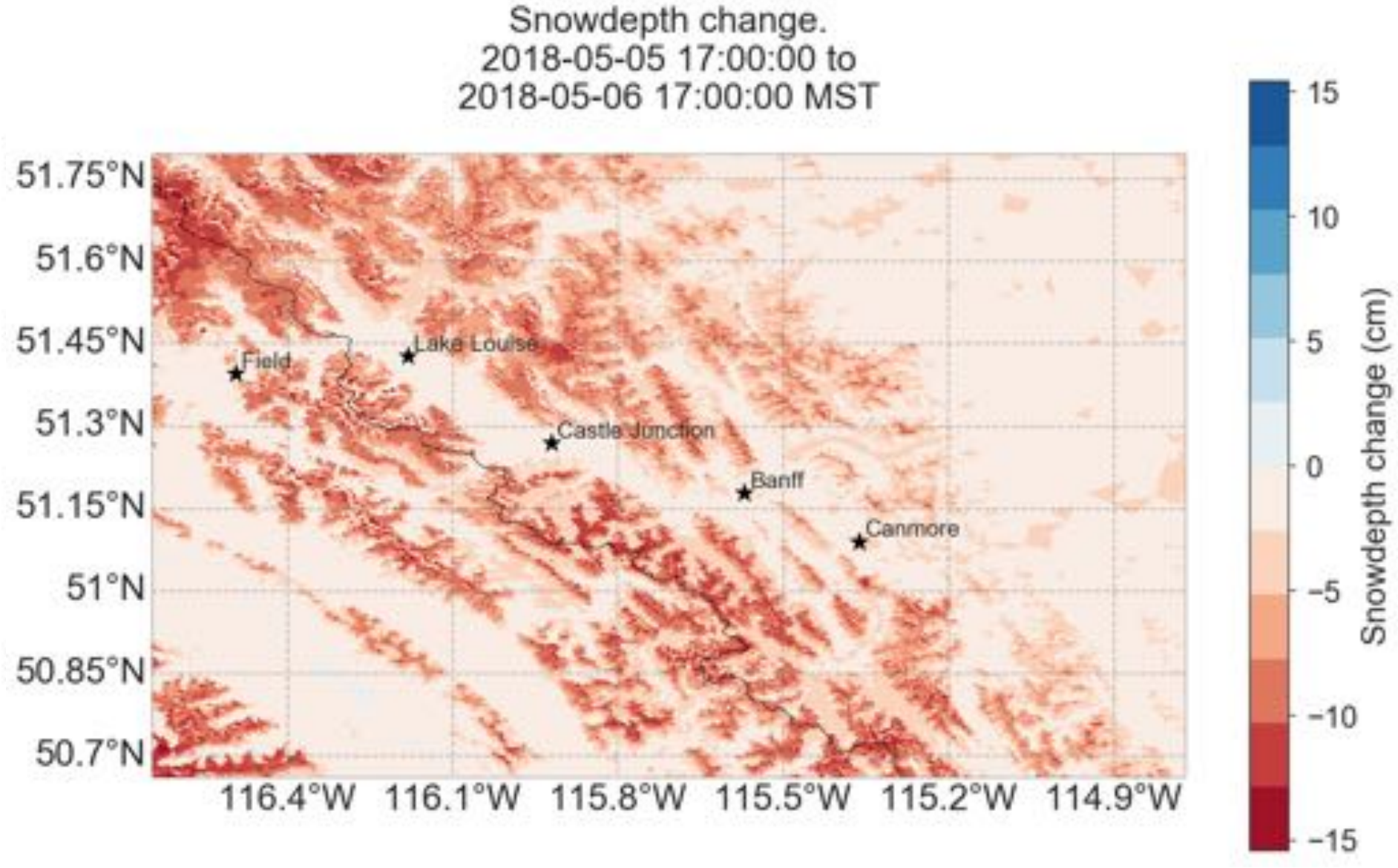


Marsh, Pomeroy, Wheater, 2018

New Coupled Multiphysics, Multiscale Models



SnowCast – Canada's Mountain Snow Forecast System

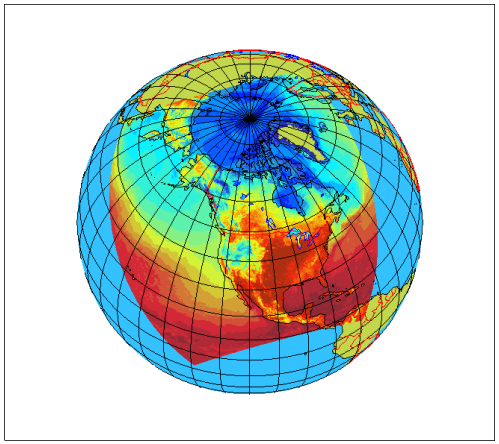


www.snowcast.ca

GEM-CHM

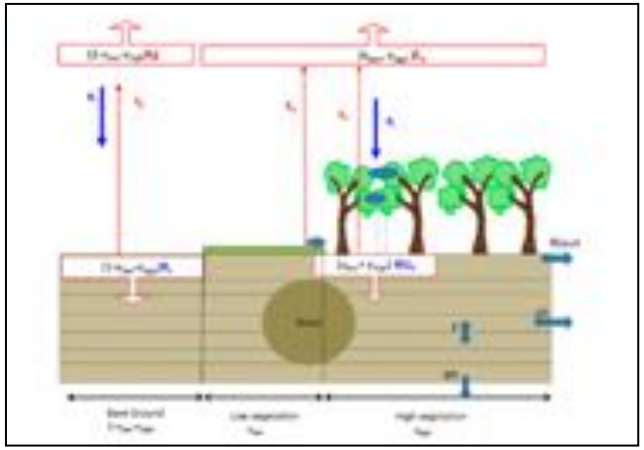
The GEM-Hydro Modelling Platform

Atmospheric forcing



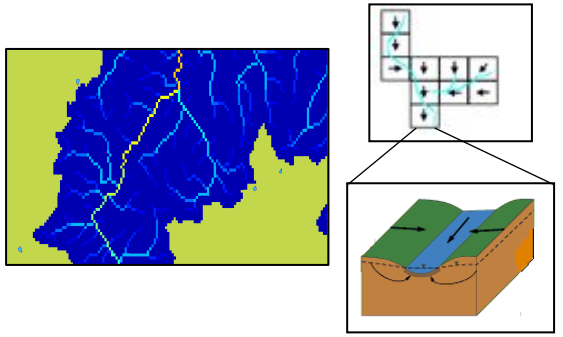
- Forecasts from the GEM model
- Canadian Precipitation Analysis (CaPA)

Land Surface Scheme
SVS (Soil Vegetation and Snow)



- Multiple energy budgets for bare ground, low and high vegetation
- Single layer snowpack scheme

Routing
WATROUTE



- Hydrological routing of surface/lateral flows and drainage simulated by SVS

A collaboration between Environment and Climate Change Canada and Global Water Futures

GEM-Hydro Simulation of 2013 Flood

Vincent Vionnet and CMC

VISIT GWF

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National Hydrology Research Centre, Saskatoon

Canadian Centre for Water Forecasting and Prediction, Saskatoon

Coldwater Laboratory, Canmore, Alberta

Global Water Futures
National Hydrology Research Centre
11 Innovation Boulevard
Saskatoon, SK S7N 3H5 Canada
Tel: (306) 966-2021; Fax: (306) 966-1193
Email: gwf.project@usask.ca
Website: www.globalwaterfutures.ca