ECCC's water cycle prediction program and Global Water Futures

Alain Pietroniro, Executive Director, National Hydrological Service, Meteorological Service of Canada and Lead - Global Water Futures Core Modelling Program

GLOBAL WATER FUTURES

SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE

Contributors

- Dr. John Pomeroy, University of Saskatchewan
- M. Michel Jean, Director General, MSC
- Dr. Vincent Fortin, Research Scientist, ECCC
- Dr. Bruce Davison, Research Scientist, ECCC
- Dr. Saman Razavi, Associate Professor, University of Saskatchewan
- Mr. Daniel Princz, Research Engineer, University of Saskatchewan
- Mr. Kevin Shook, Research Engineer, University of Saskatchewan
- All members of the core modelling team and many others

Context for Water Resources

- ECCC has a series of mandated responsibilities for water resources and it management in Canada
- In 2013, MSC recognized the convergence of interest and capacity between MSCs national hydrometric program delivered through the Water Survey of Canada and its transboundary water management obligations.
- A National Hydrological Service was developed as a new forward-looking vision to optimize and consolidate existing MSC program elements.
- More recently the desire for a national framework for prediction in water resources is being discussed
  - Meet transboundary requirements
  - Work with Provinces and Territories for flow guidance systems tied to NWP

Model calculations – HPC power – Fore

Forecast qu

30
20
10
0

CDC
Cray
NEC
IBM

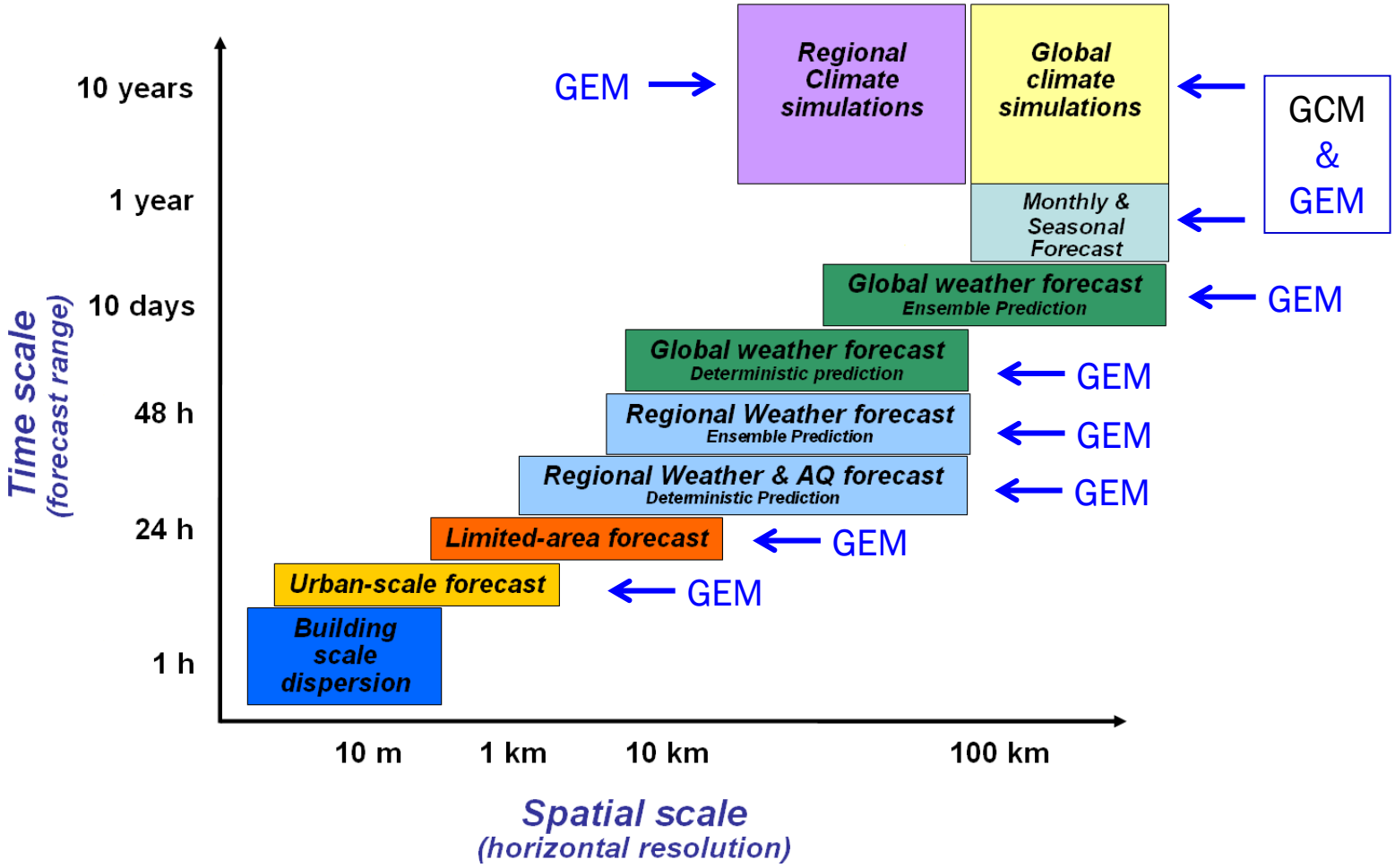
1.0E+01
1.0E+00
1.0E-01
1.0E-02

Mflo

Model calculatio

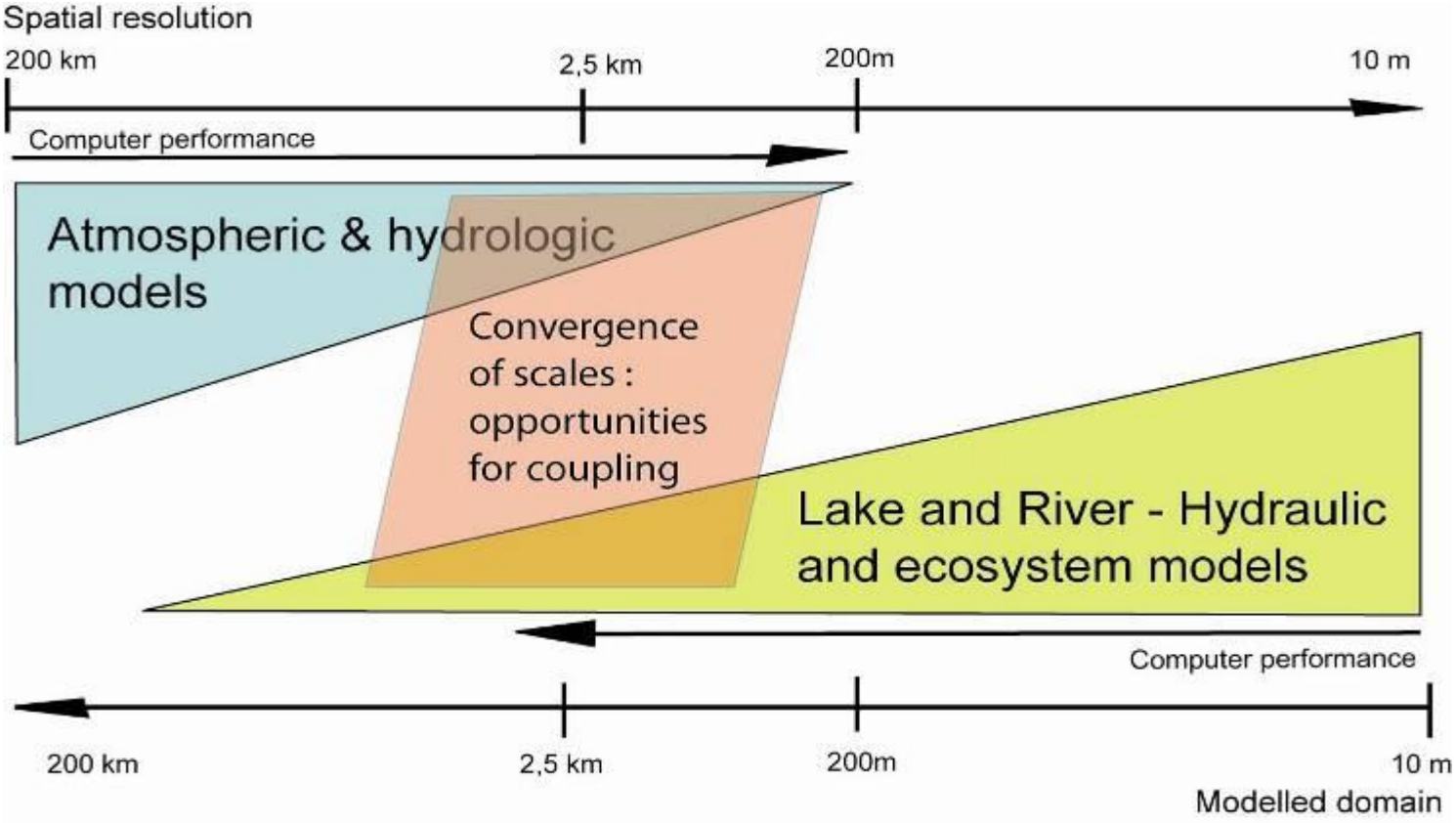
1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016

Modeling systems running on ECCC supercomputer



Why hydrologic, lake, river and ecosystem model applications are emerging?

- Established models exist for most components
- Modeling scales are converging



Why GWF and ECCC and Why Now ?

- Hydrology still not completely defined, particularly Cold Regions
  - Dealing with spares data systems, incorporating cold regions processes, basin segmentations and physics, data assimilations ….
- No systematic water quality models have been implemented
  - No In-stream quality systems e.g. (WASP)
  - No non-point pollutions models operational
  - No lake quality modelling systems
- Hydraulic models currently limited in ECCC systems
- No DSS implemented
- No water management

At ECCC we recognize Current Hydrological Approaches are Limited

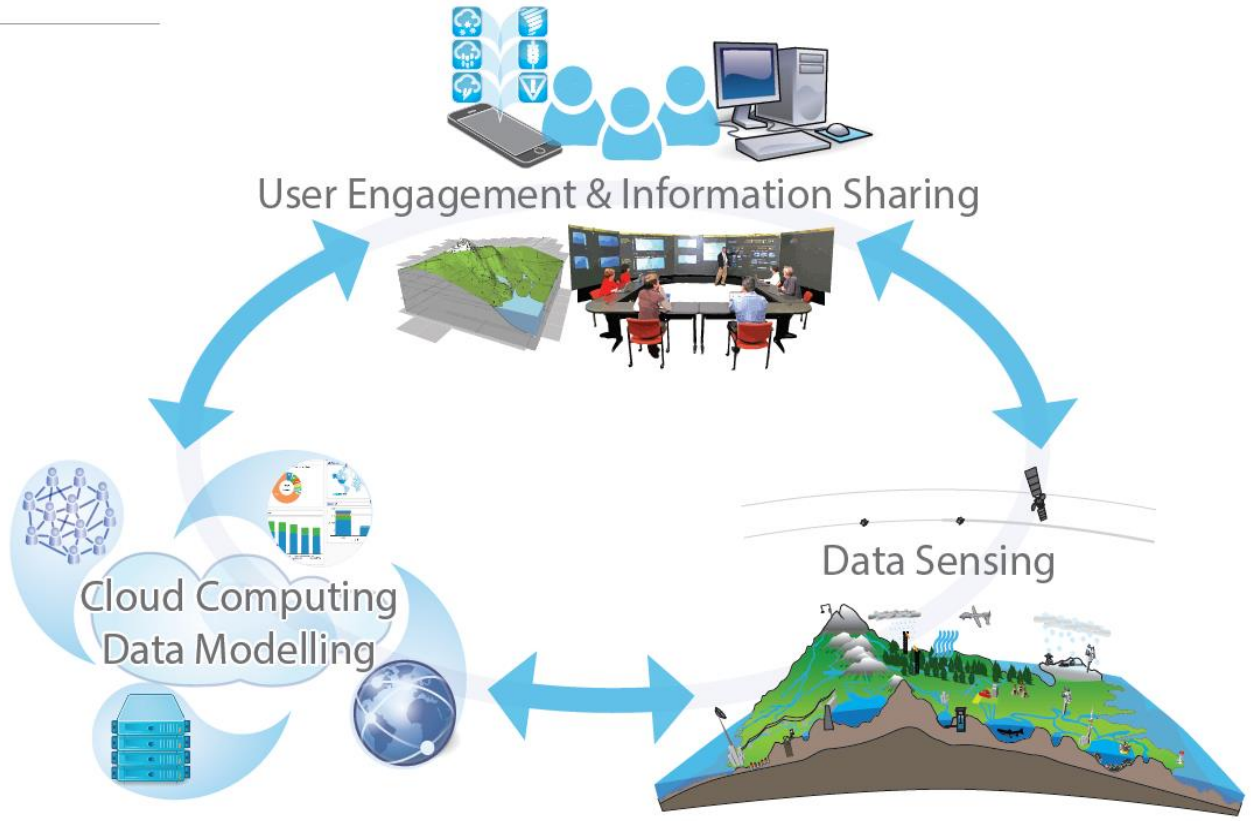
- Hydro-mythology : *Concepts that have been dismissed by scientific investigation but persist in hydrological model (*Pomeroy)
- Examples:
  - Radiation is difficult to estimate with normal meteorological data
    - Evapotranspiration can be estimated by temperature and wind functions
    - Temperature index melt of snow and soil thaw
  - Snowfall determines snow available for melt
    - Sublimation = 0
    - Snowfall gauge correction = snow redistribution loss
  - Soils can be represented as uniform porous media and subjected to clever mathematical manipulations
    - Macropores = 0
    - Green-Ampt or Richard's Eq. can work "as is" or are still physically based when heavily calibrated from streamflow
  - All land surfaces drain freely to streams with quick flow at overland flow velocities
    - Hortonian overland flow
    - Contributing area = 100%
  - Frozen soils behave like unfrozen soils
    - Calibration of unfrozen soil infiltration for frozen conditions

GWF National Water Observation and Prediction Strategy

GLOBAL WATER FUTURES
SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE

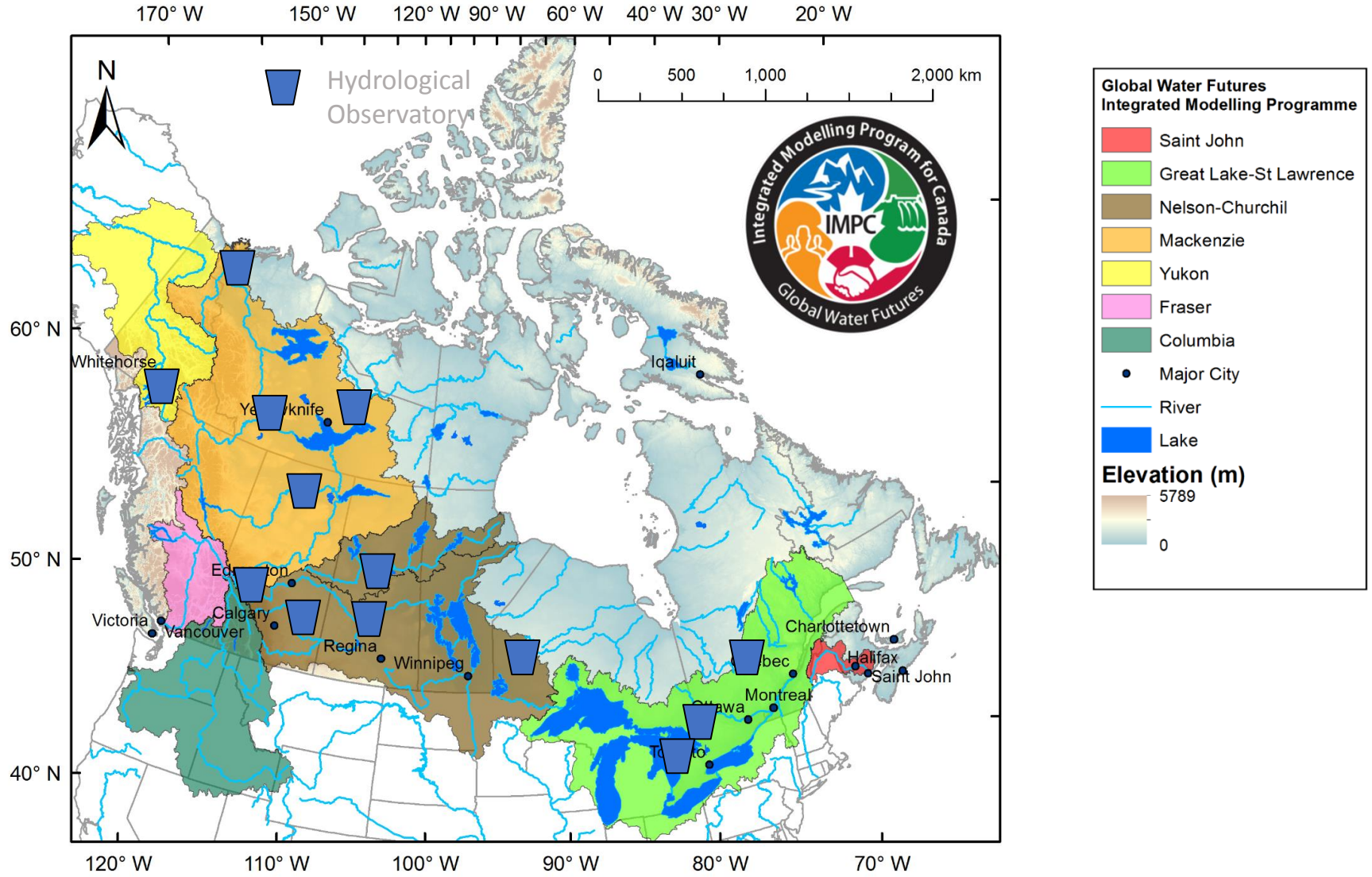
- **Core support teams to deliver national modelling capability, advanced computer science, new observational science and knowledge mobilization**
- **User-question led project-focussed funding**

- **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)**



GLOBAL WATER FUTURES
SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE

ECCC and GWF National Water Prediction Strategy



Some GWF Models

- Atmospheric Models or Forcing
  - GEM (Canadian NWP), WRF, CaPa
- Climate Models Outputs,
  - GCM, CRCM policy runs, Pseudo-Global Warming with WRF
- Coupled Atmospheric –Hydrology Systems
  - GEM Hydro, MESH, WRF Hydro
- Non-point pollution models such as Sparrow, MAGIC, HYPE
- Instream water quality models such as WASP
- Transport Models
  - PorousMediaLab, MatSedLab
- Stand-alone Hydrology Models
  - Cold Regions Hydrological Model (CHRM), MESH (includes a variant of ISBA, CLASS) , Canadian Hydrological Model-next generation, VIC, HYPE
- Decision Support and Water Management Models such as MODSIM and WEAP
- Lake Models
  - MyLake model suite, ELCOM-CAEDYM,Nemo

CORE OUTCOMES

- The modelling core project will focus on creating a common platform for scientists from various disciplines and different universities/institutes to work together. The focus on the first 3 years will
  - Develop and apply new coupled modeling systems that integrate regional climate, land management, hydrology and water management over climate change sensitive regions.
  - Improve models with the capability to explore and assess how changes in population, economic development, and land use will impact water resource management and water quality, in addition to climate change.
  - Determine how state-of-the-art model scenarios and predictions can be best framed to inform decision making, policy and adaptive governance for the management of risks from hydrological change to water resources.

Core Team – Modelling & Forecasting

- Hydrological and Water Quality Forecasting
  - **Flood Forecasting**
  - **Seasonal and Drought Forecasting**
  - **Floodplains**
  - **Data Assimilation**
  - **River Ice Modelling**
  - **Water Quality**
- Climate and Diagnostic Hydrology and Water Quality Modelling
  - **Climate - high resolution pan-Canadian**
  - **Hydrological Modelling**
  - **Next Generation Water Modelling**
  - **Catchment, River and Lake Water Quality**
- Water Resources Systems

ECCC Grant

- Dan Princz – MESH community model development
- Nassim Hosseini – SWOT and Hydraulic model development

Center for Hydrology

-Tom Brown – CRHM development

- Dominique Richard – MESH forecasting and testing – Yukon and Bow

ECCC modelling Team

- Fortin, Gaborit, Dunford, others GEM Hydro development
- Bruce Davison/Anthony Liu /Frank Seglenieks– MESH development

University Teams

- Saman Razavi – VIC/MESH development and IMPC
- Bryan Tolson – IMPC inter-comparison
- Trish Stadnyk – IMPC, HYPE, Isotopes

GWF Model Principles

- Open-Source models if possible
- Consistent meta-data approaches to model runs
- Strong version control
- “Digestible “ by use community
- Linking and coupling of various modelling sytems
  - Common formats between models if possible
  - Shared tools

- Core modelling team starting to work closely with Core computing team
  - Visualization
  - Model efficiency
  - Sophisticated data handling tools
  - Basin processing software

GLOBAL WATER FUTURES
SOLUTIONS TO WATER THREATS IN AN ERA OF GLOBAL CHANGE

Dealing with Forecasting and Forcings

FloodNet NSERC

CaSPAr
Canadian Surface Prediction Archive

Juliane Mai, **Kurt Kornelsen**, David Schäfer, Bryan Tolson, Paulin Coulibaly, François Anctil, Vincent Fortin, Michael Leahy, Brent Hall

University of Waterloo
McMaster University
Université Laval
compute canada
Environment and Climate Change Canada
Environnement et Changement climatique Canada
Helmholtz Centre for Environmental Research – UFZ
esri
NSERC CRSNG

CaSPAr Status Report ECCC-CMC
October 24, 2017

Summary

- Given the size, data realities and complex hydrology conditions in Canada, a very systematic and detailed modelling framework was developed at ECCC in collaboration with university to deal with those realities.
- A precipitation assimilation system was developed and operationalized in ECCC to deal with the sparse nature of the atmospheric observations.
- A community H-LSS framework that could be tested offline for improved physics, parametrization, segmentation, optimization and sensitivity analysis was needed.
- Offline MESH-Model (using CLASS) shows promise in hindcast mode where many other models have failed.
  - Systematic inclusion of non-contributing areas, glaciers, water management were necessary to make the model work.
- GEM-Hydro (using a modified version of ISBA), along with NEMO for the Great Lakes basin show much promise for short term forecasting. We expect better results, particularly in complex terrain and cold regions with SVS.
- Because of the community-based approach, recent funding of GWF and a federal need to develop a national water modelling platform, MESH and GWF models will provide the necessary community platform for model integration and systematic testing and evaluation moving towards eventually operationalizing the system.
- GWF will be pivotal in moving our ECCC hydrology, water quality, Large Lake and Water Management modelling foreword
- We look forward to the continued collaboration.

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