



Environnement et
Changement climatique Canada

Environment and
Climate Change Canada

NUMERICAL ENVIRONMENTAL PREDICTION AND SERVICES

Canadian Centre for Meteorological and Environmental Prediction,
Meteorological Services of Canada
And
Meteorological Research Division
Atmospheric Science and Technology Directorate,
Science and Technology



Canada 

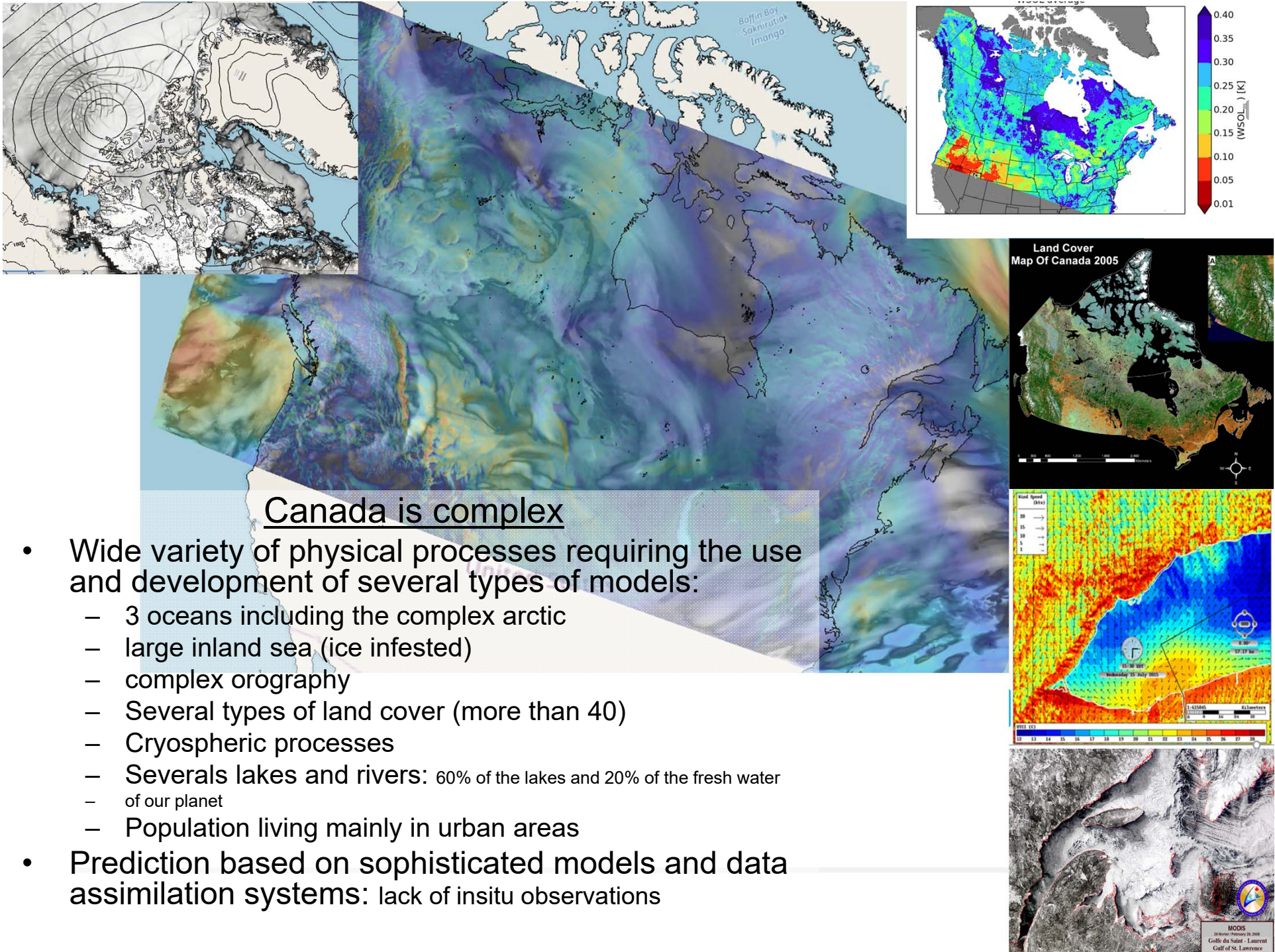
15 July 2019, ISWG, Montreal

OVERVIEW

- Context and Vision: Environmental Prediction
 - Components:
 - Soil-Vegetation-Snow and Urban
 - Rivers and Lakes
 - Water Cycle Prediction
 - Ocean-Ice-Waves
 - Emergency response
-

CONTEXT AND VISION

- Delivery of a science-based service: Science for Services
 - Deliver the underpinning science necessary to advance the prediction system **through strong national and international coordination and collaborations**
 - Co-design our prediction systems that rely on research advances
 - Develop an integrated approach to research, development and operation
-



Canada is complex

- Wide variety of physical processes requiring the use and development of several types of models:
 - 3 oceans including the complex arctic
 - large inland sea (ice infested)
 - complex orography
 - Several types of land cover (more than 40)
 - Cryospheric processes
 - Several lakes and rivers: 60% of the lakes and 20% of the fresh water of our planet
 - Population living mainly in urban areas
- Prediction based on sophisticated models and data assimilation systems: lack of insitu observations

The surface systems

OBS
Surface
Satellites
Radars



Canadian
Land
Data
Assimilation
System

Atmospheric
forcing from
ECCC's
systems



Canadian
Precipitation
Analysis

Geophysical
description

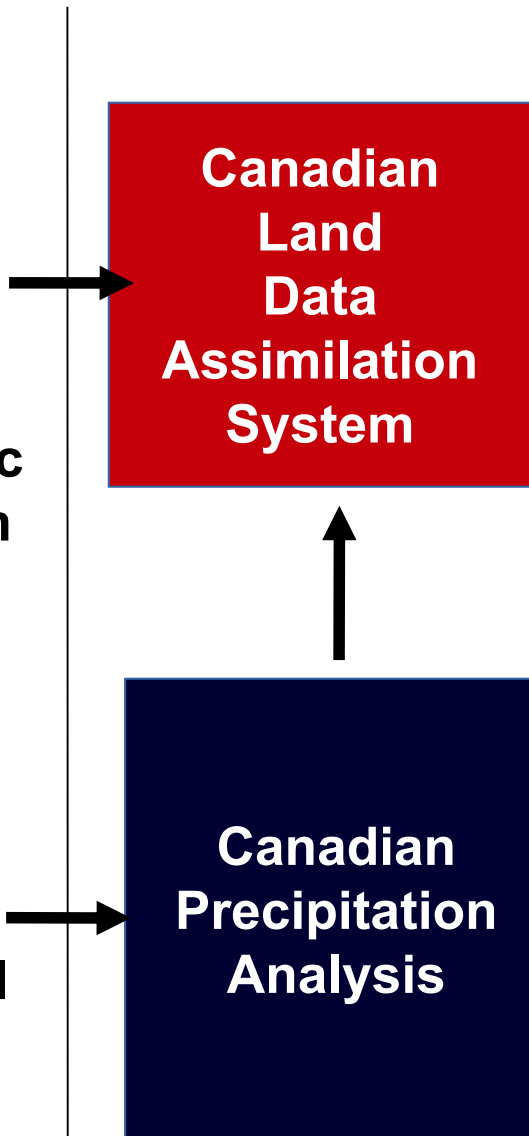


The surface systems

OBS
Surface
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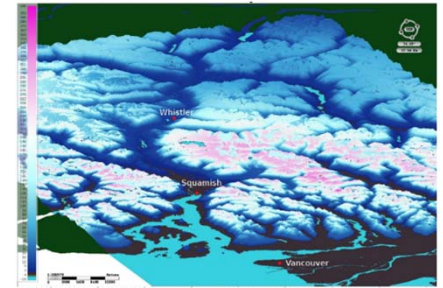
Geophysical
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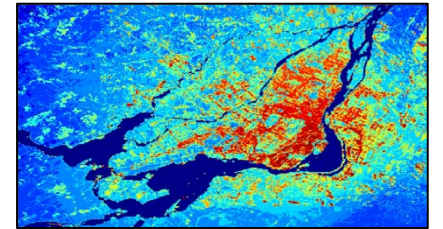
PRODUCTS
ANALYSES →

Environmental Prediction
Systems

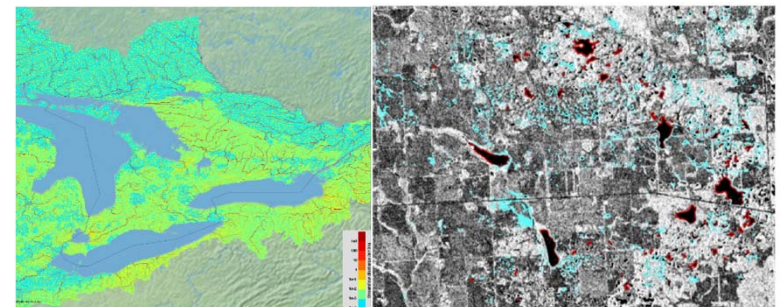
Land ...
Soil /
Veg /
Snow



Cities



Hydrology, Lakes and Oceans





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Hydrological and Water Cycle Prediction Program

Research/Innovation/Development/Operations for:

Improved Water Information and Services for
Water Resource Management, Water Security and
Forecasting of Floods and Droughts

Objectives

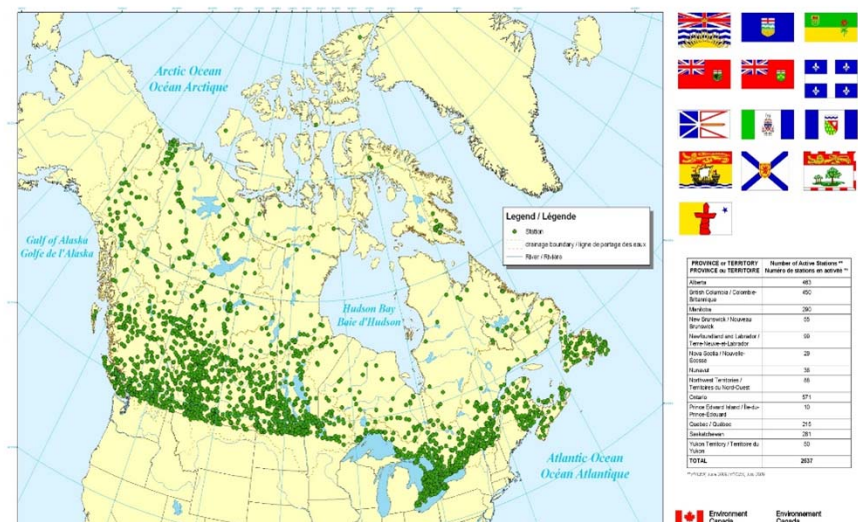
- Key clients

- National Hydrometric Program and MSC operational offices
- DND and other departments
- Provinces and Territories
- Specialized Users (through products disseminated via Datamart/Geomet)
- International Joint Commission Boards of Control and Study Boards

To manage lake and river systems along the border between Canada and the United States: To protect them for the benefit of today's citizens and future generations.



National Hydrometric Program
Programme national de relevés hydrométriques



Page 8 – July



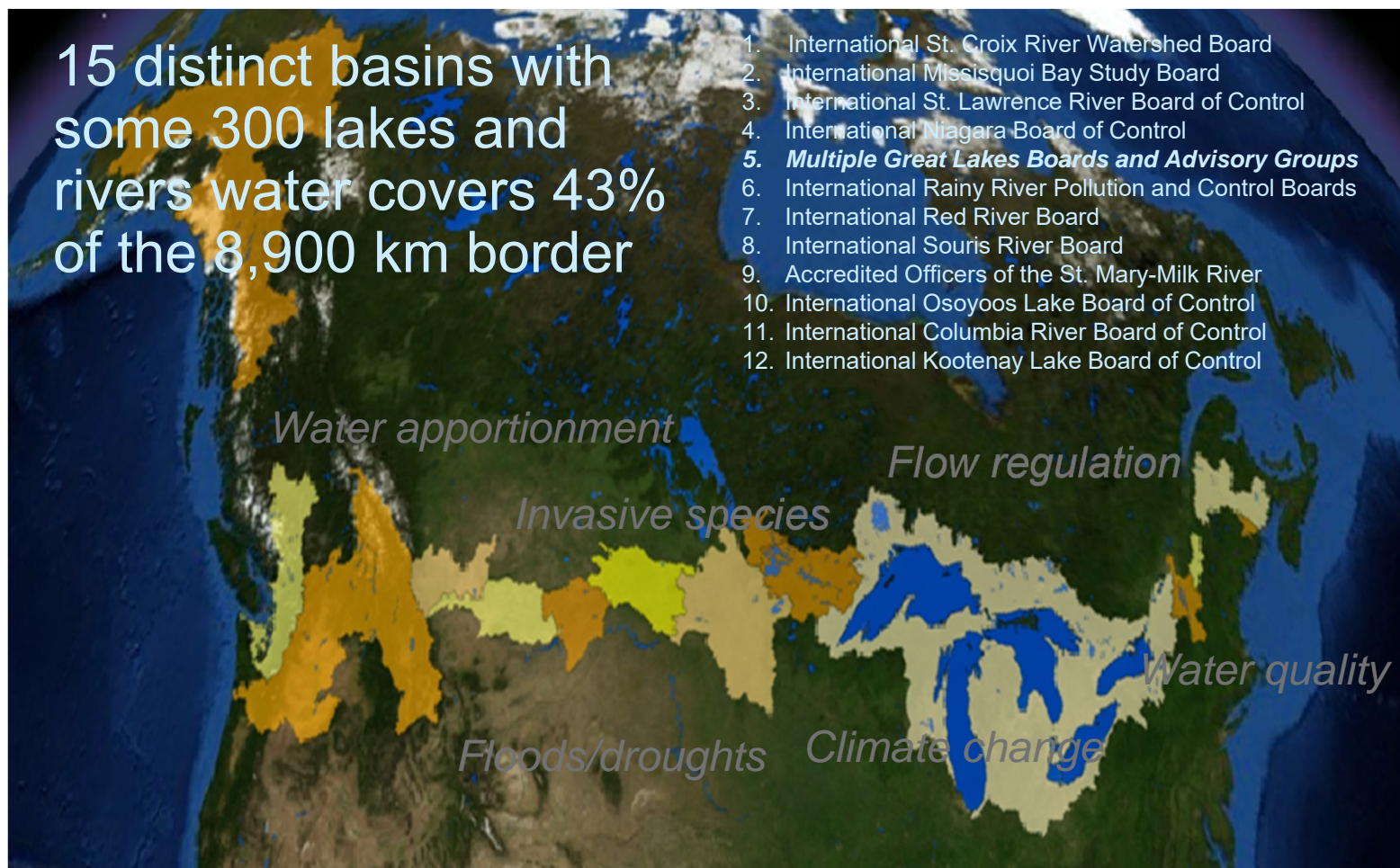
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A numerical laboratory infrastructure in support to IJC: Boards Address a Range of Issues

15 distinct basins with
some 300 lakes and
rivers water covers 43%
of the 8,900 km border

1. International St. Croix River Watershed Board
2. International Missisquoi Bay Study Board
3. International St. Lawrence River Board of Control
4. International Niagara Board of Control
5. **Multiple Great Lakes Boards and Advisory Groups**
6. International Rainy River Pollution and Control Boards
7. International Red River Board
8. International Souris River Board
9. Accredited Officers of the St. Mary-Milk River
10. International Osoyoos Lake Board of Control
11. International Columbia River Board of Control
12. International Kootenay Lake Board of Control



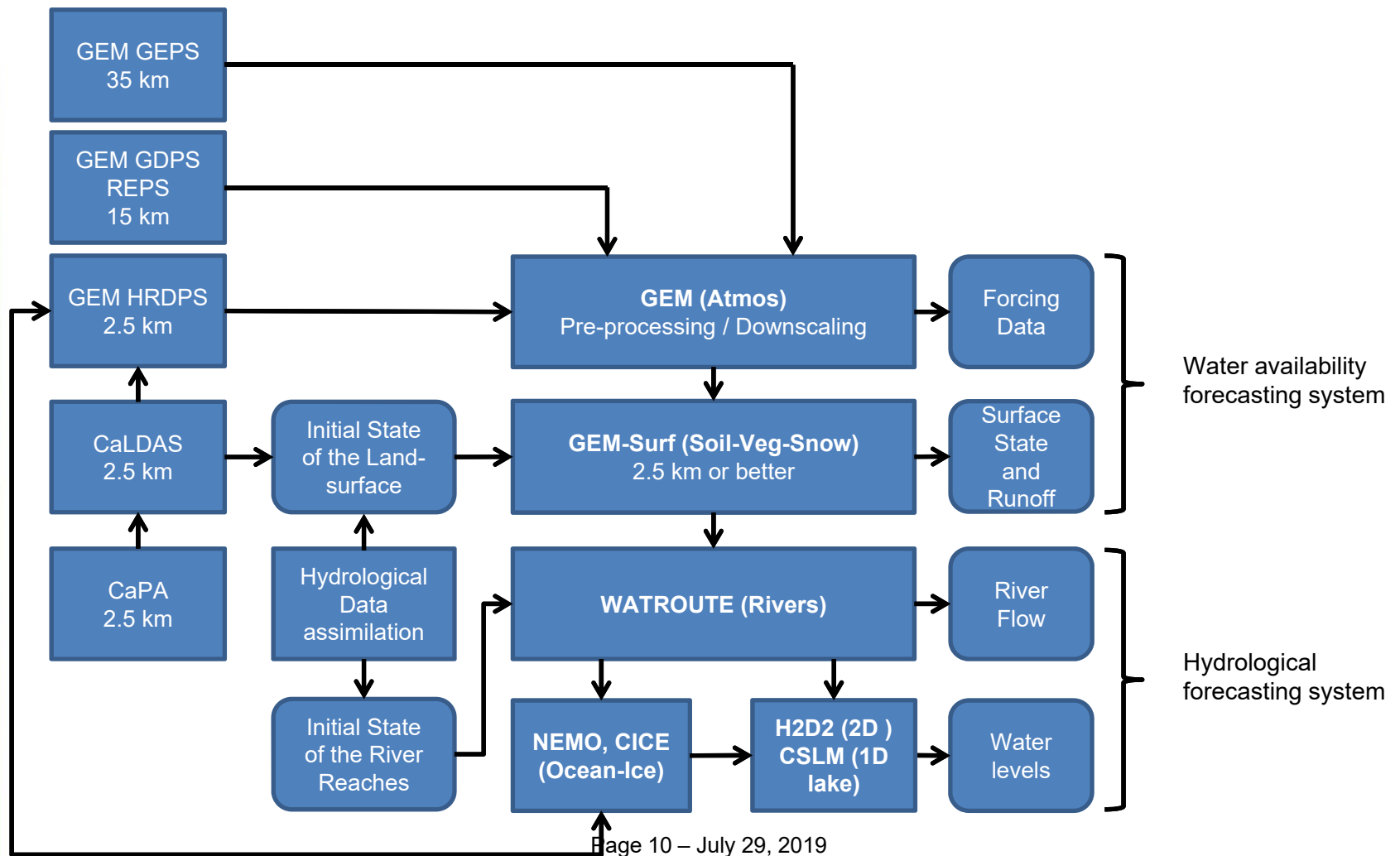
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Vision for the hydrological forecasting system



Page 10 – July 29, 2019



Weather & Environmental Forecasts - The Need for Coupled Atmosphere-Ice-Ocean Prediction

ECCC requires ice-ocean forecasts and information services for:

- Improved weather and waves prediction
 - Time scales: from days to seasons
 - Sea ice, tropical cyclones, surface interactions
 - Initialization of seasonal forecasts
- Sea ice prediction
 - Improved automated analyses and forecasts
 - Dangerous high pressure areas
- Emergency response
 - Comprehensive trajectory modelling capacity
 - E.g. dispersion of pollutants
- Collaboration with other GoC departments and Mercator-Ocean
 - Fisheries and Oceans, Coast Guard
 - National Defense

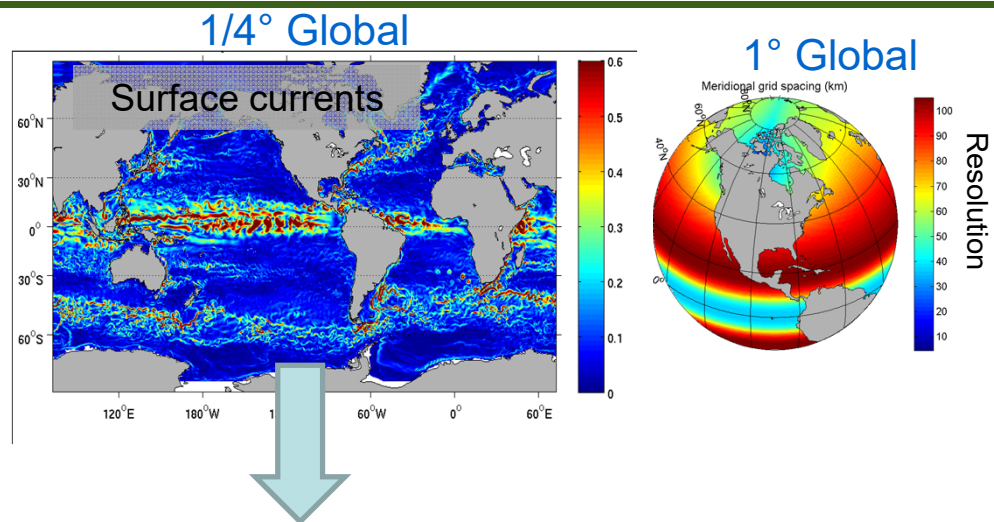


Status of Ice-ocean modelling

Operational
Experimental
In development

Applications and domains

- Global 1/4° resolution (GIOPS)
 - Medium-to-Monthly forecasting
 - Coupled Deterministic (GDPS)
 - Coupled Ensembles (GEPS; monthly)
- Global 1° resolution (CanSIPS-GN)
 - Seasonal forecasting



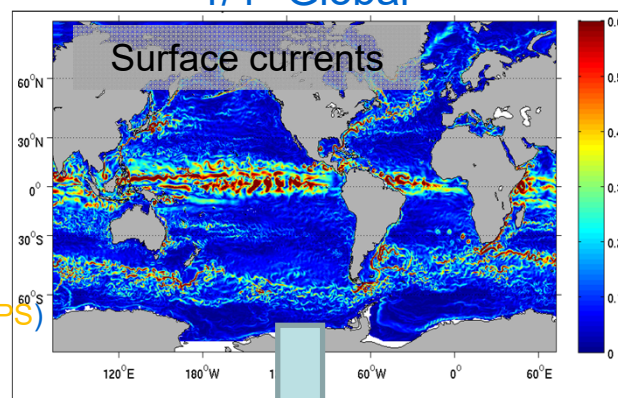
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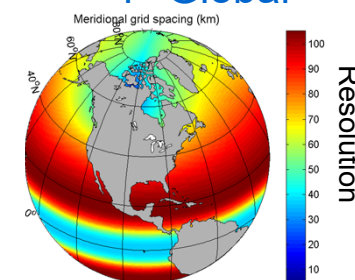
Applications and domains

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 - Seasonal forecasting
- N. Atlantic-Pacific and Arctic $1/12^\circ$ (RIOPS)
 - Short-term forecasting
 - Coupled with 3km GEM for YOPP
- Great Lakes 2km (RMPS-GL) & Gulf of St. Lawrence 5km (RMPS-GSL)
 - Short-term forecasting

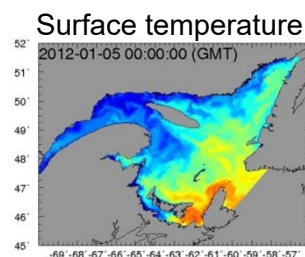
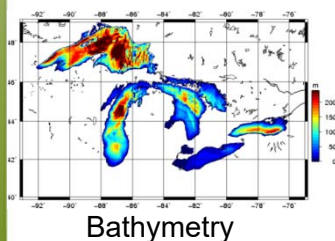
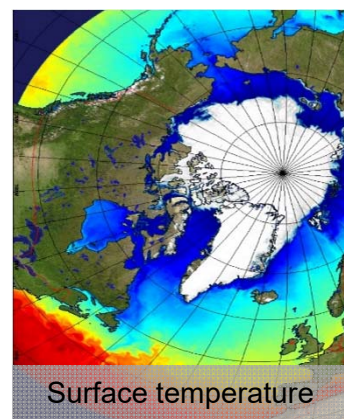
$1/4^\circ$ Global



1° Global



$1/12^\circ$ N. Atlantic and Arctic

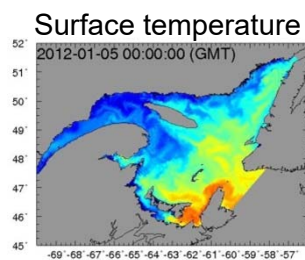
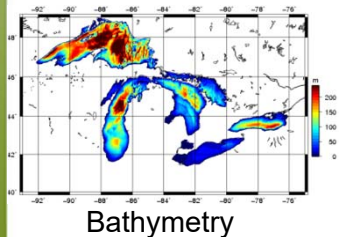
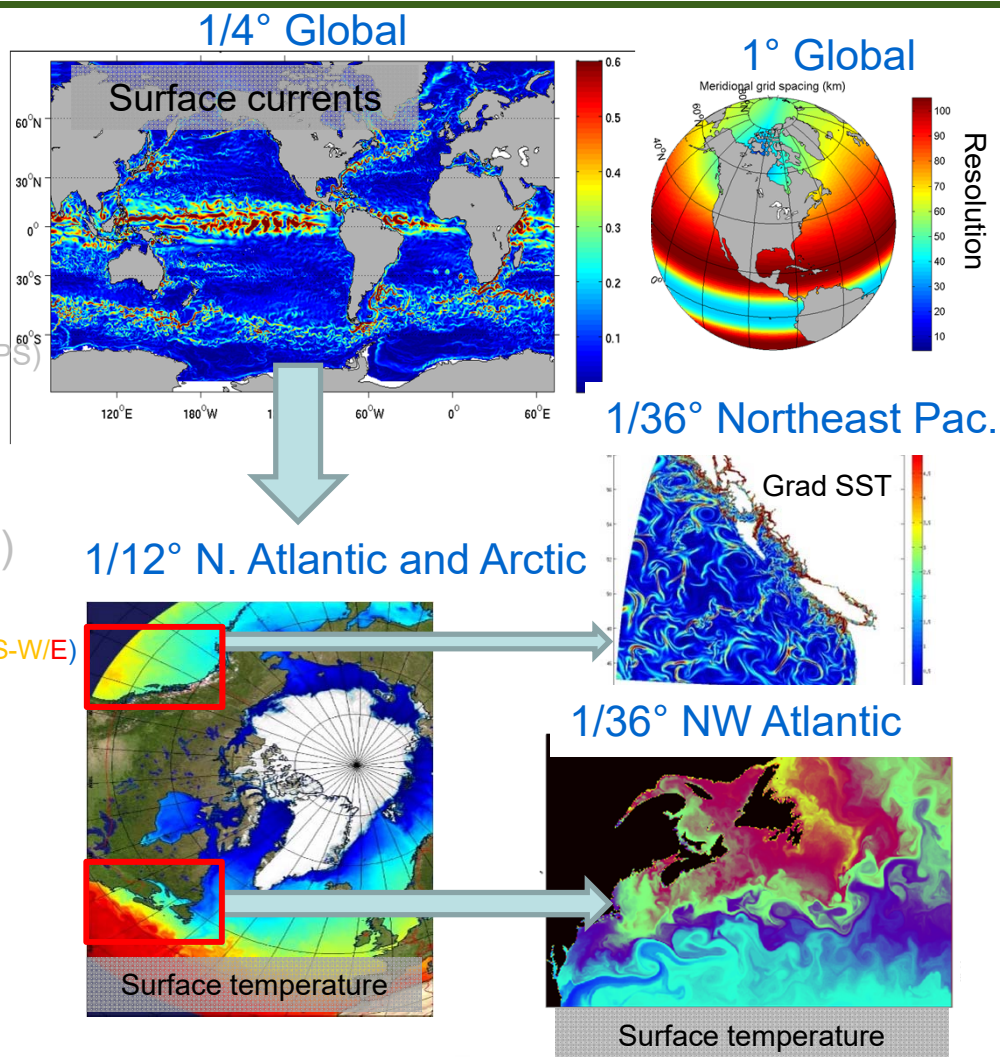


Status of Ice-ocean modelling

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Applications and domains

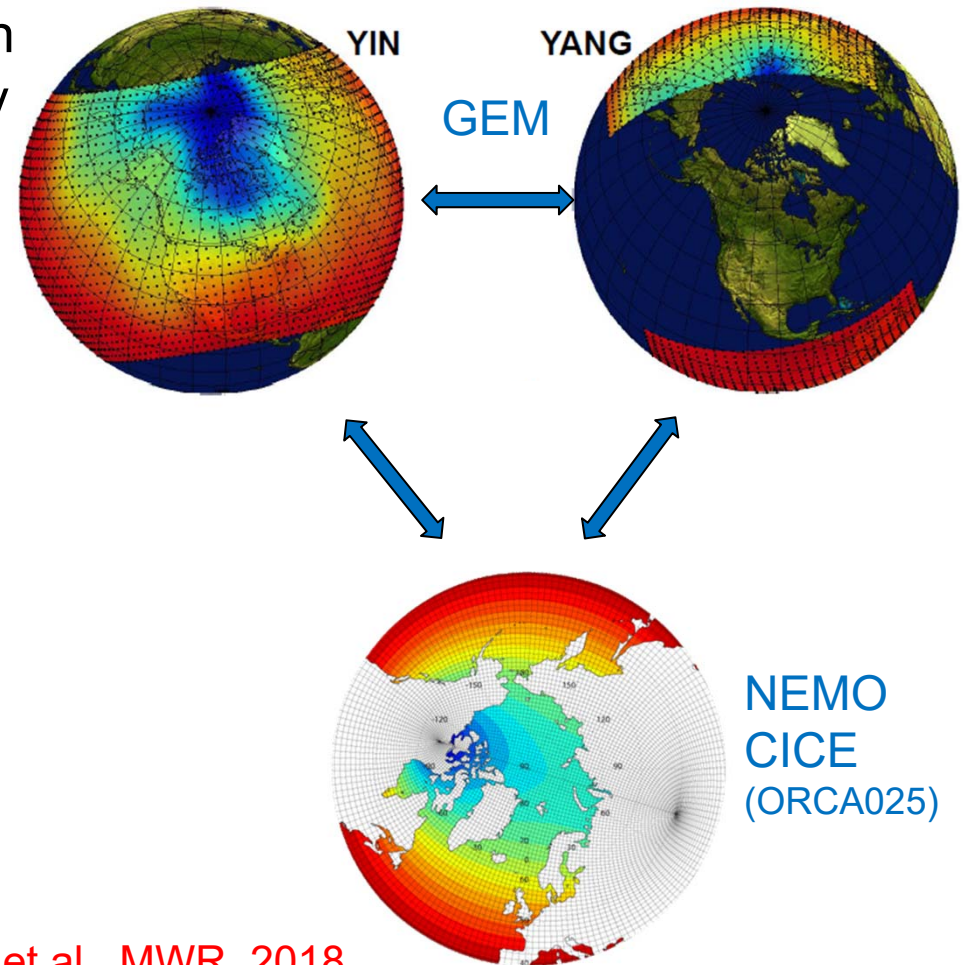
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- Short-term forecasting
- Coastal Environmental Prediction (CIOPS-W/E)
 - Emergency response, SAR



Global Coupled Medium-range Deterministic Forecasts



- Coupled NWP system running in operations at CCMEP since July 2016:
 - GDPS coupled to GIOPS
 - Global, fully-coupled A-I-O, 15 km(A)-1/4deg(IO),
 - GEPS coupled to GIOPS
 - Seasonal
- In future will couple with wave models as well.



Smith et al., MWR, 2018



Environment
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Fisheries and Oceans
Canada



National
Défense
Défense
nationale



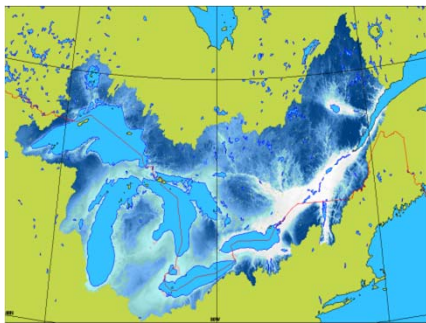
Mercator
Ocean
Ocean Forecasters

Canada

Great Lakes and St. Lawrence Water Cycle Prediction System

Durnford et al., BAMS, 2018

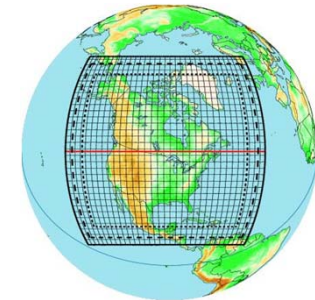
WATROUTE
routing model (1km)



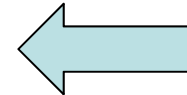
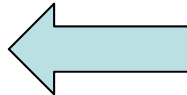
GEM LAM (10 km)
atmospheric model
(ISBA land-surface scheme)



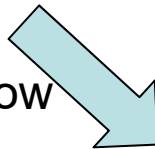
GEM RDPS (10 km)
atmospheric model



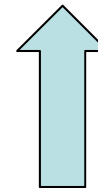
Runoff



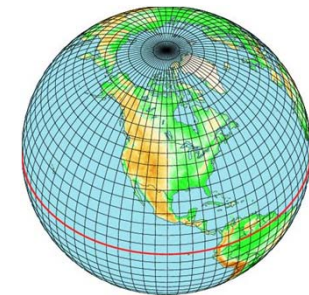
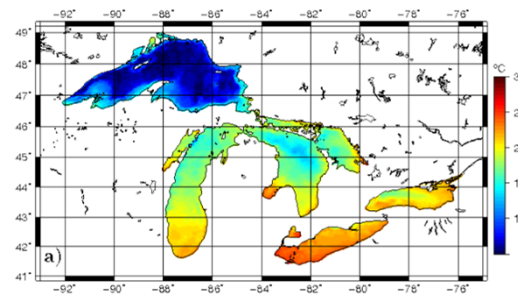
Streamflow



Turbulent fluxes



- 2 forecasts/day (00Z and 12Z)
- 48-h forecasts
- Assimilation cycle: direct insertion of RADARSAT ice cover and WSC streamflow



NEMO+CICE (2 km)
ocean-ice model

GEM GDPS (25 km)
atmospheric model

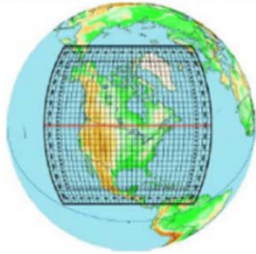


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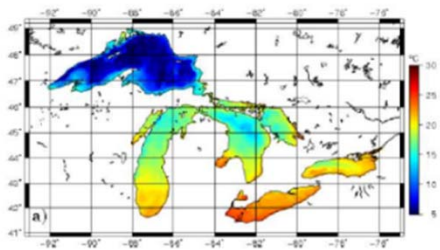
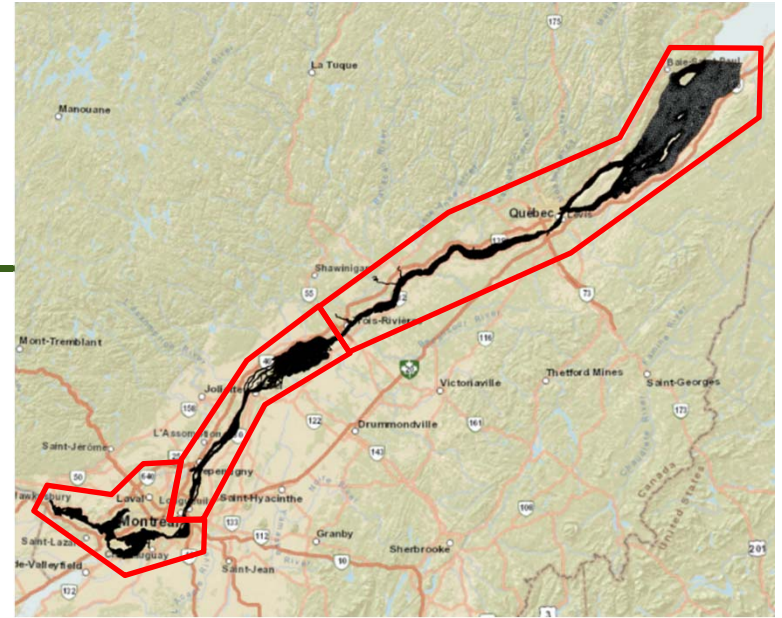
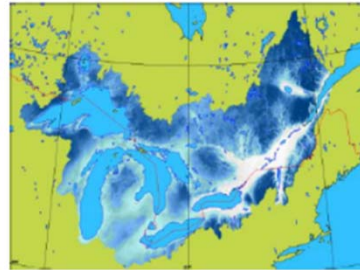
Environnement
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In development: St-Lawrence River and Gulf

**GEM HRDPS (2.5km)
atmospheric model
(SVS land-surface scheme)**

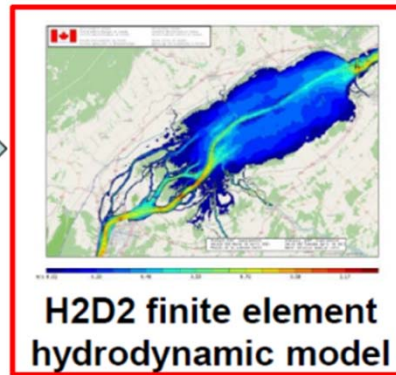
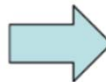


**WATROUTE
routing model (1km)**

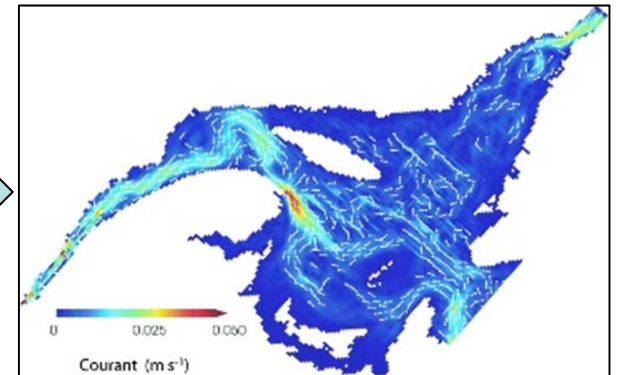
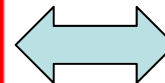


**NEMO+CICE (2 km)
ocean-ice model**

**NEMO+CICE (500m – 5km)
ocean-ice model**



**H2D2 finite element
hydrodynamic model**

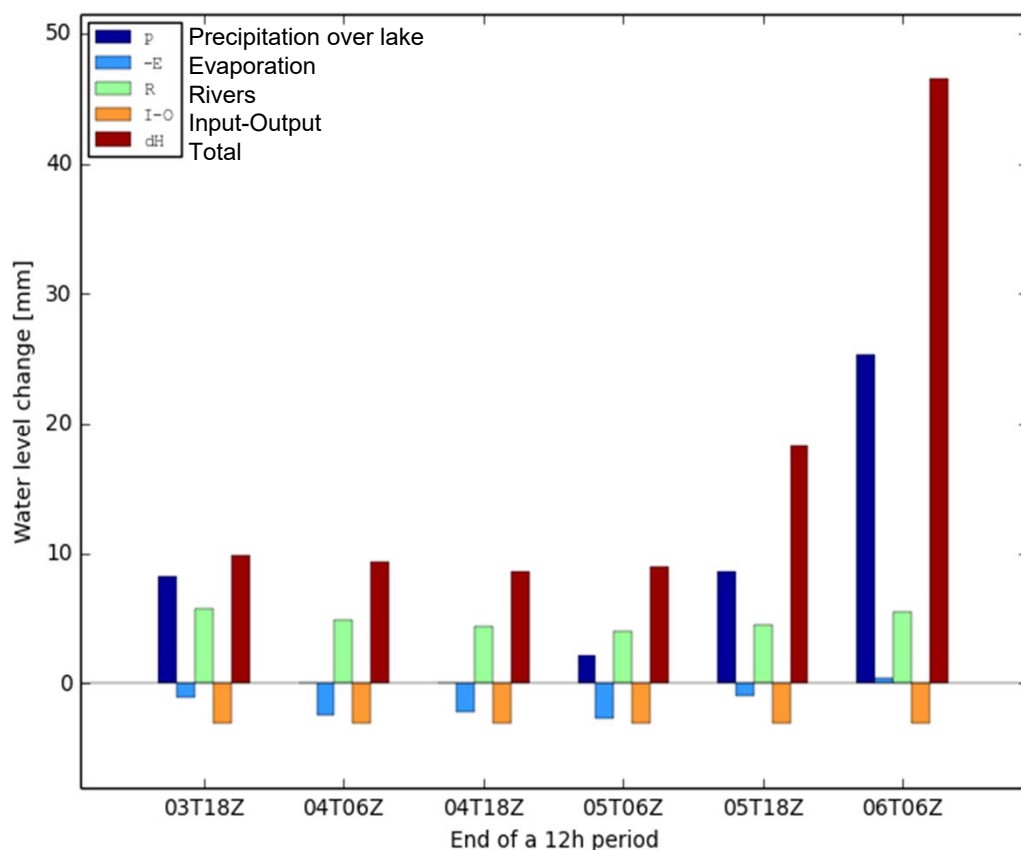


PREDICTED FIELDS OF INTEREST

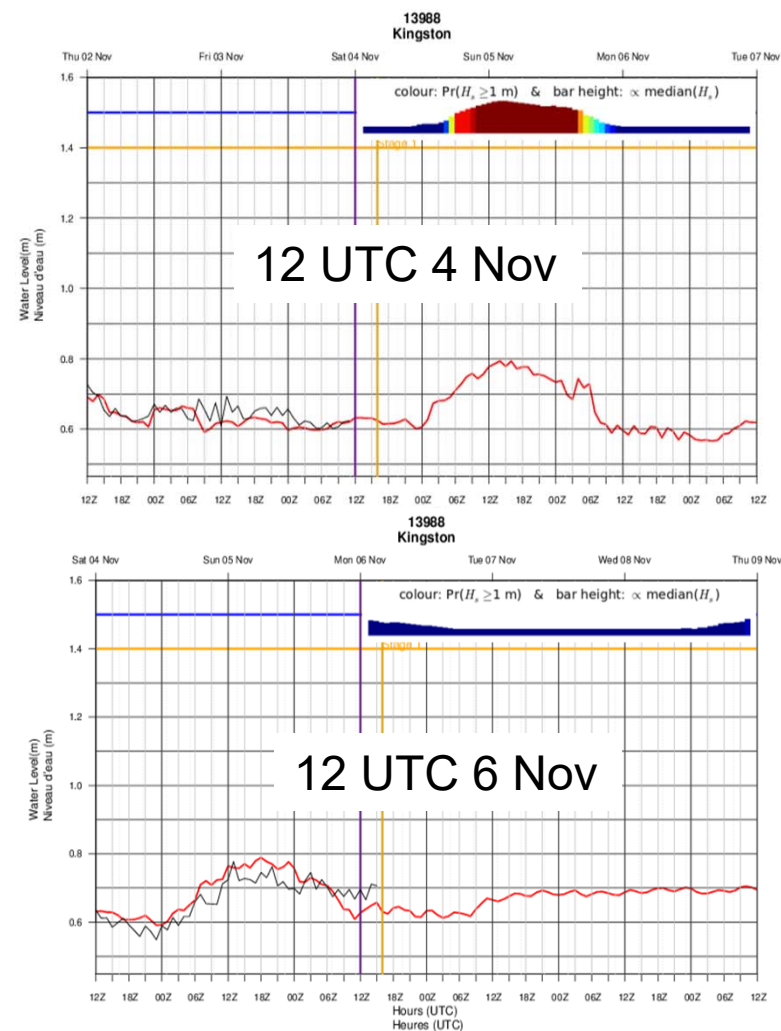
- Atmosphere (10-km resolution):
 - surface runoff over land
 - precipitation (P) onto and evaporation (E) from lake surfaces
 - Rivers (1-km resolution):
 - river flows
 - terrestrial runoff into lakes (R)
 - Lakes (2-km resolution):
 - water level, surface water temperature, surface currents
 - lake ice concentration and thickness
 - Component Net Basin Supply (NBS):
 - $P - E + R$
-

PRODUCT FOR LAKE ONTARIO

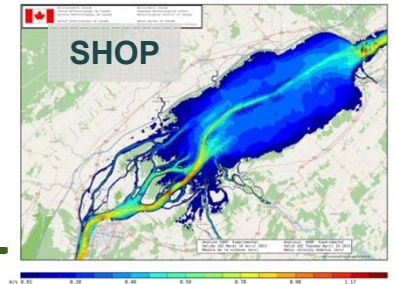
Forecast water budget components: Lake Ontario
Water Level Change



Forecast change in base water level at Kingston and forecast waves.

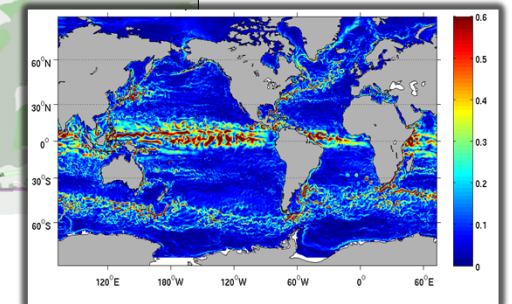
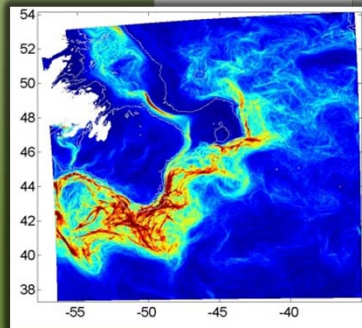
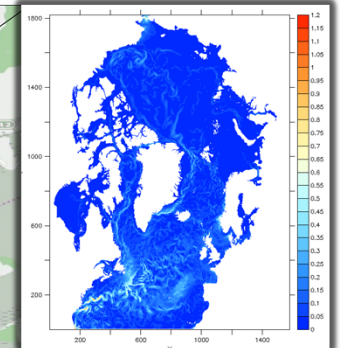
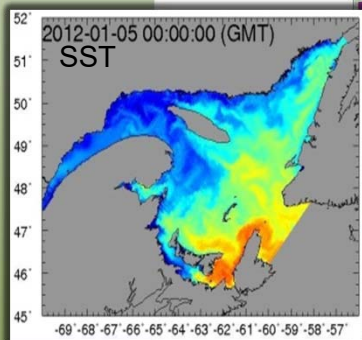


Oil Spill Modelling



Developing an ECC's Canadian Oil Spill Modelling Suite fully connected to CCMEP environmental fields

- Powerful Lagrangian transport and dispersion
- Incorporate sophisticated fate and behaviour modules
- Forecast movement and evolution of oil spill and other HNS in water
- Flexible, fast, scalable system & always up-to-date
- Connected to CCMEP environmental fields, easier technological transfer from research to operations



Waves and Storm Surge



- **Regional Deterministic / Ensemble Storm Surges Prediction System (RD/ESPS)**
 - RDSPS was developed to provide hourly water level forecasts.
 - RESPS (1 control and 20 perturbed members) is used to capture the uncertainty in initial conditions and evolution of the weather over the next 10 days.
 - Forecasts of the risk of exceeding critical water level thresholds are drawn from RESPS for a series of selected periods (e.g., probability of an excess during day 6).
- **Global Deterministic Wave Prediction System(GDWPS)**
 - First EC global wave forecast system.
 - Will soon be augmented by the GEWPS (1 control plus 20 perturbed members).
 - Will allow probabilistic forecasts of occurrence of conditions such as risk of Hs exceeding 6m on day 5.
- **Great Lakes Deterministic and Ensemble Wave Forecast Systems**
 - Were developed to improve wave guidance for the PanAm Games (Toronto 2015)
 - Used all summer over lake Ontario to help identify areas at risk of exposure to large waves.
 - A parallel implementation is scheduled for October.

Services in a nutshell

- Current and future state of the environment:
 - Atmospheric and urban conditions
 - Ocean-Ice-waves conditions: including storm surges and seiches, ice pressure
 - Hydrological and water cycle conditions: drought, flood, water availability, snow cover and snow water equivalent
 - Soil-vegetation conditions: moisture and temperature
 - Precipitation: type and quantity
- Data products disseminated to the public and specialized Users through tailored big data web services via Datamart/Geomet

Questions and Discussion

