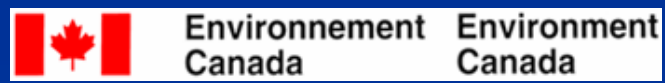
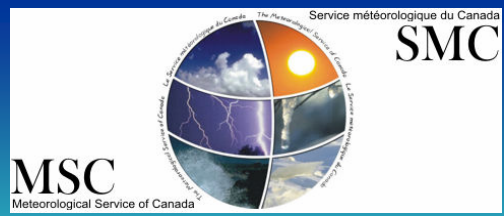
MESH*: A Canadian Community Hydrologic Prediction System

**Modélisation Environnementale: Surface et Hydrologie*

V. Fortin[1], A. Pietroniro[2], P. Pellerin[1], B. Davison[3]

[1] RPN: Numerical prediction research, Meteorological Service of Canada (MSC)
[2] NWRI: National Water Research Institute
[3] HAL: Hydrometeorology and Arctic Lab, MSC





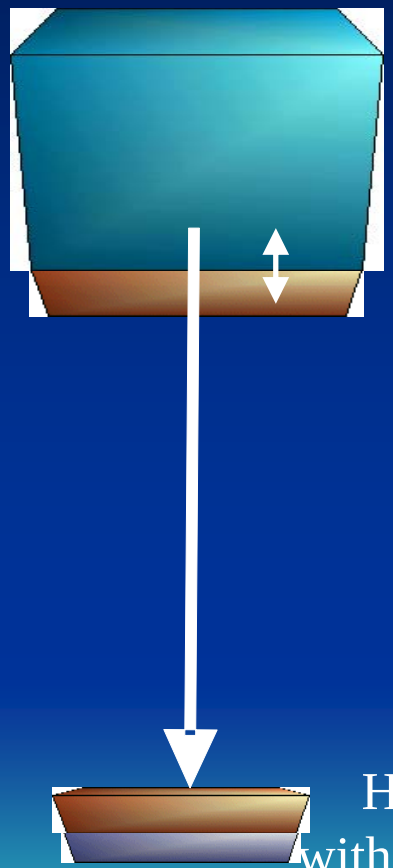
MEC and MESH

- MEC: A community environmental modelling system:
  - Stands for *Modélisation Environnementale Communautaire*
  - Multi-model / Multi-grid model driver and coupler
  - Should become the model driver for operational NWP in LAM mode at MSC
- MESH: A community hydrologic prediction system within MEC:
  - Stands for MEC – Surface and Hydrology

Outline of the presentation

- An overview of MEC and MESH
- A word on the Canadian atmospheric EPS
- Hydrological predictions with MEC/MESH
  - Snow cover
  - Streamflow forecasts
  - Reservoir inflow forecasts

Streamflow forecasting: current paradigm

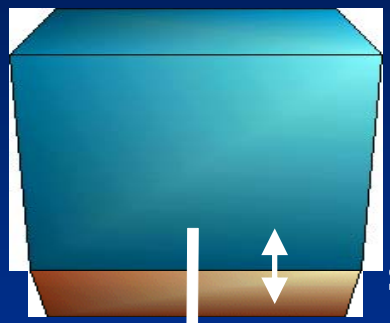


Atmospheric
model (3D)
with its own
surface scheme (1D)

Adaptation of atmospheric
model forcings

Hydrological model (lumped or 2D)
with its own land-surface scheme (SVAT)

MEC: make the surface scheme an independent component



Atmospheric model (3D) with its own surface scheme (1D)

Adaptation of atmospheric model forcings

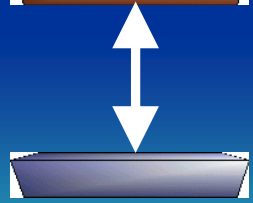
Hydrological model (lumped or 2D) with its own land surface scheme

Atmospheric model (3D)

"On-line" mode

"Off-line" mode

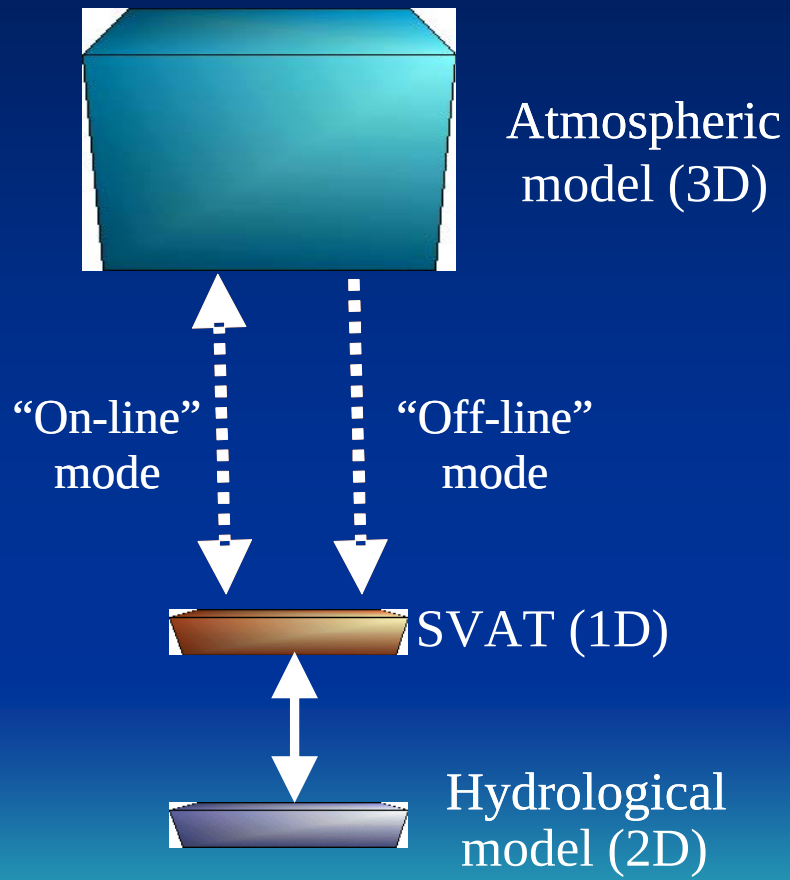
SVAT (1D)



Hydrological model (2D)

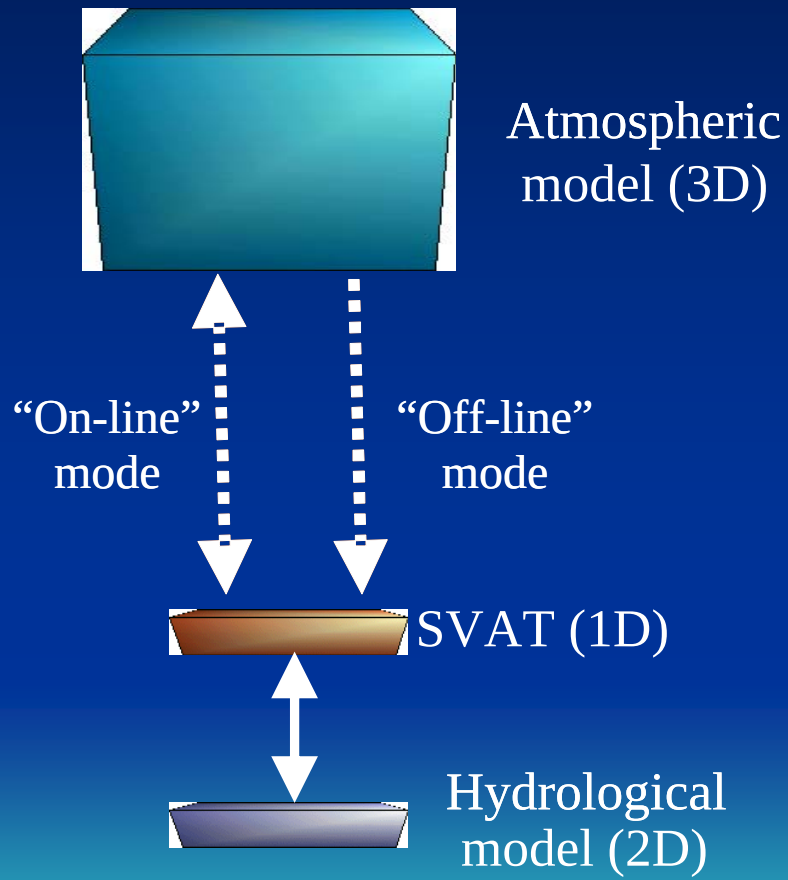
MEC: a hydrometeorologic model driver

- Built from the GEM atmospheric model driver
  - Benefits from all of the I/O pre- and post-processing software, including a powerful GUI for visualizing model outputs



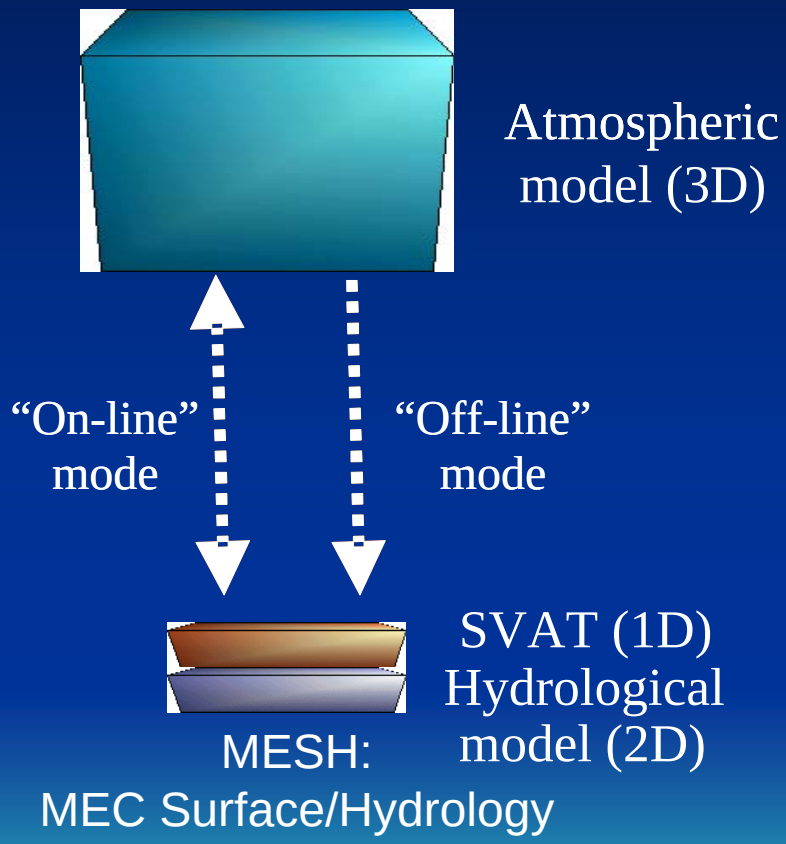
MEC: a hydrometeorologic model driver

- Models available within MEC:
  - Atmosphere: GEM
  - Surface: force-restore, ISBA, CLASS, WATFLOOD
  - Hydrology: GRU approach based on WATFLOOD
- Uses MPI for parrallel processing
- It is quite simple to make surface/hydrological simulations offline at high resolution and over a large domain
  - e.g. with reanalyses or archived forecasts



MEC/MESH mode

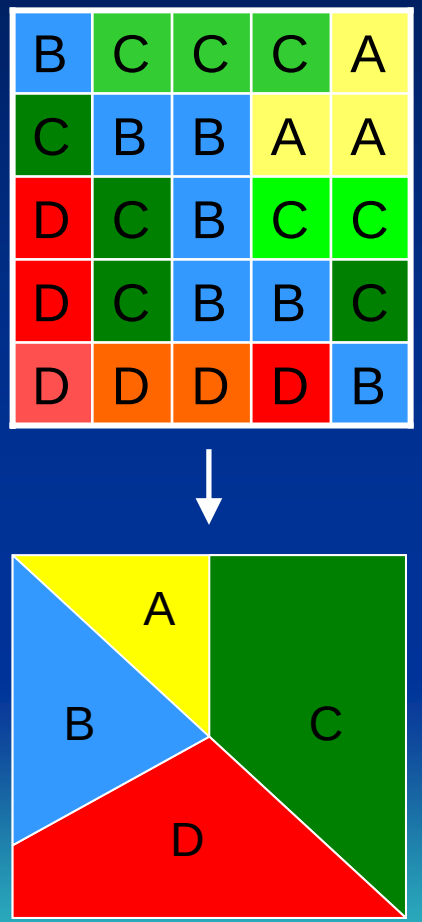
- The surface model is less costly to run than the atmospheric model, and can benefit from a higher resolution
  - It can be run at the resolution of the hydrologic model
  - The SVAT and the hydrologic model can then be closely linked to better parameterize subgrid-scale processes
  - The atmospheric and hydrological models still share the same SVAT



MESH: A MEC surface/hydrology configuration designed for regional hydrological modeling

- Designed for a regular grid at a 1-15 km resolution
- Each grid divided into grouped response units (GRU or tiles) to deal with subgrid hetereogeneity
  - based on WATFLOOD

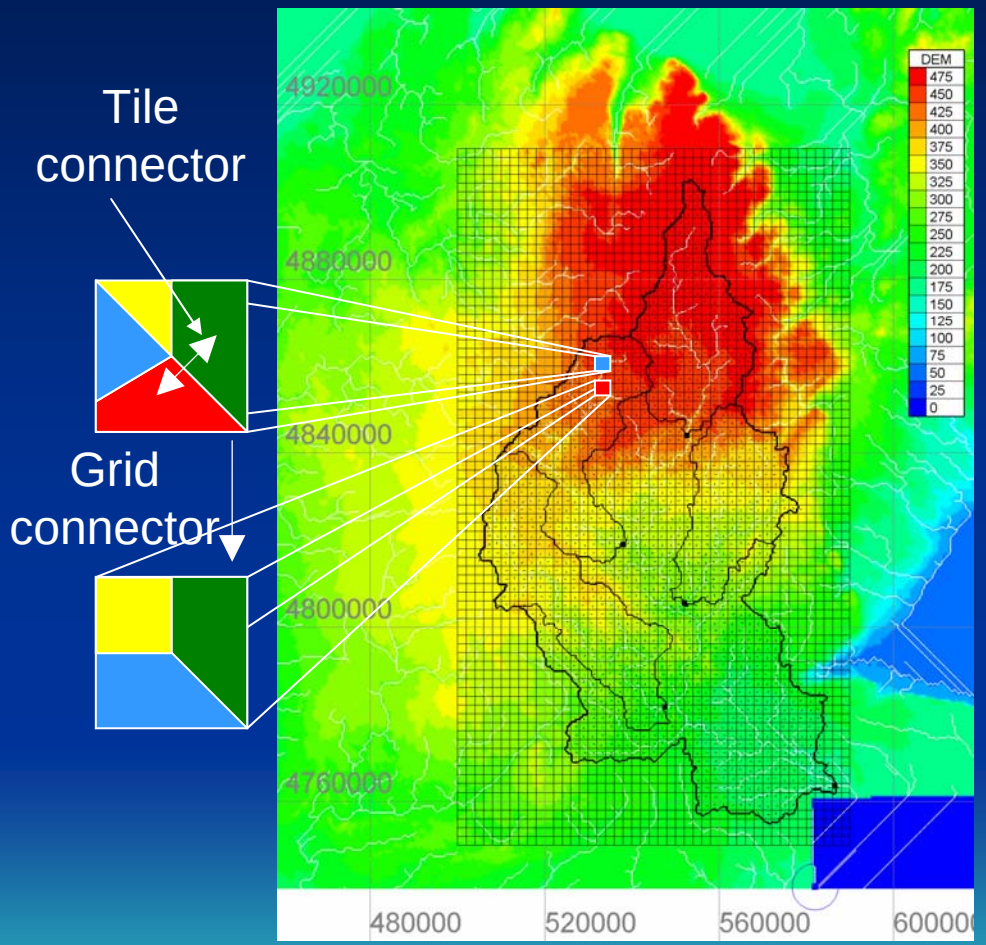
Sub-grid Hetereogeneity (land cover, soil type, slope, aspect, altitude)



A relatively small number of classes are kept, only the % of coverage for each class is kept

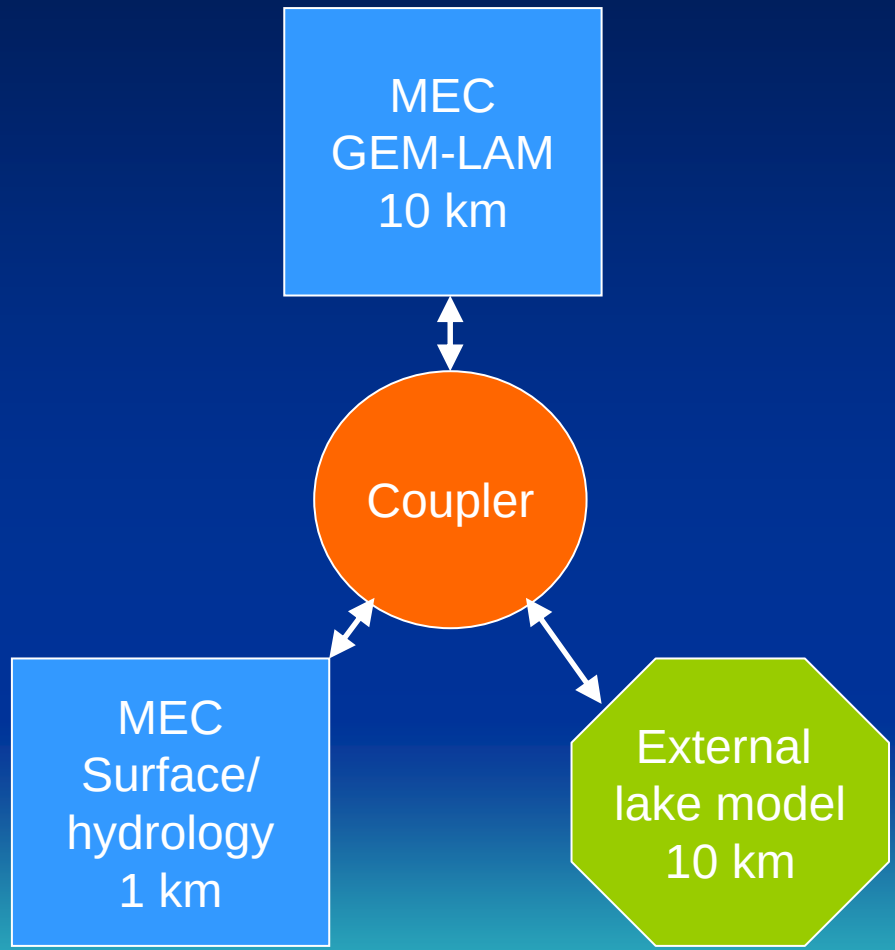
MESH: A MEC surface/hydrology configuration designed for regional hydrological modeling

- The tile connector (1D, scalable) redistributes mass and energy between tiles in a grid cell
  - e.g. snow drift
- The grid connector (2D) is responsible for routing runoff
  - can still be parallelized by grouping grid cells by subwatershed



OASIS/Gossip: the coupler

- Different instances of MEC are assigned one or many roles (atmosphere, surface, hydrology, ocean) and a grid
- One or many roles can be assigned to an external application
- The coupler allows all instances to send and receive info. on their grid
- RPN coupler (Gossip) recently merged with OASIS developed by CERFACS (Toulouse) and used for the EU PRISM project



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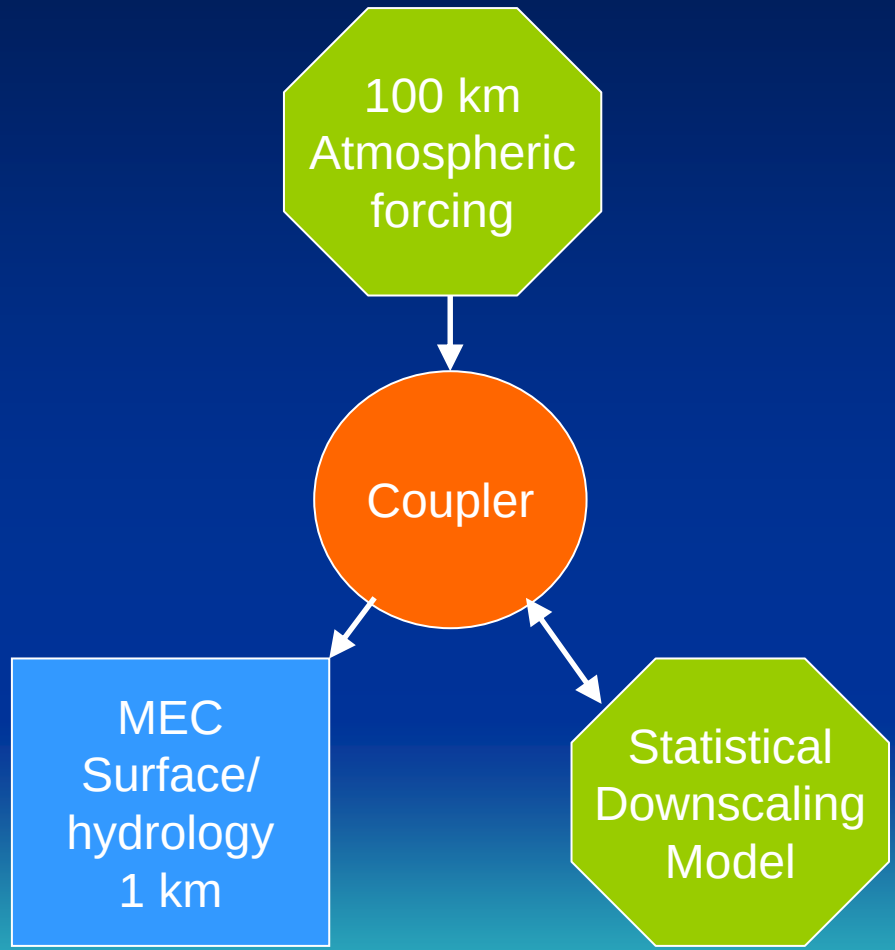


The Canadian EPS

Multi-model ensemble (SEF + GEM)

- T149 for SEF, 1.2º for GEM
- A different parameterization is used for each member

Since June 2001:

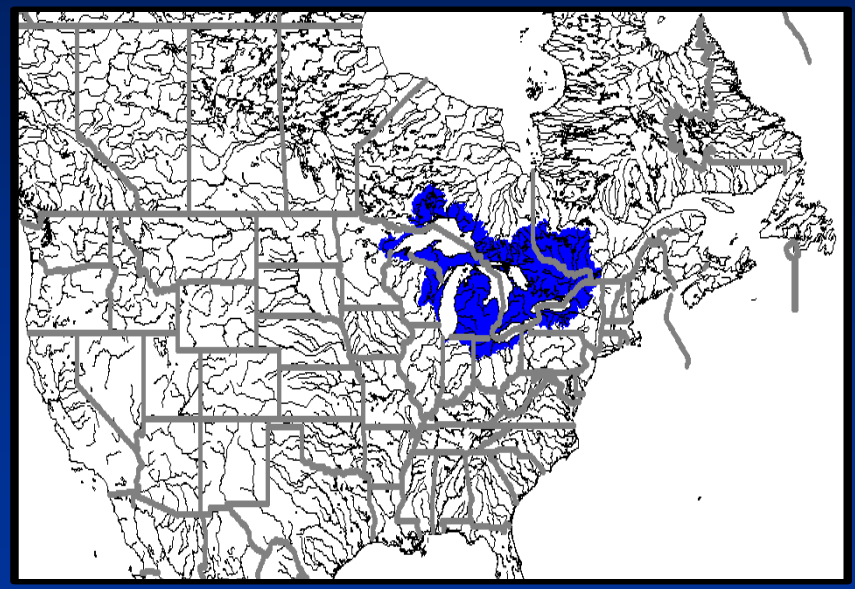
- 10 day runs once a day
- 8 perturbed runs from each model
- Surface scheme:
  - force-restore

Starting January 2006:

- As part of the NAEFS:
  - 15 day runs twice per day
  - 10 perturbed runs from each model
  - Surface scheme:
    - 10 members with F-R
    - 10 members with ISBA

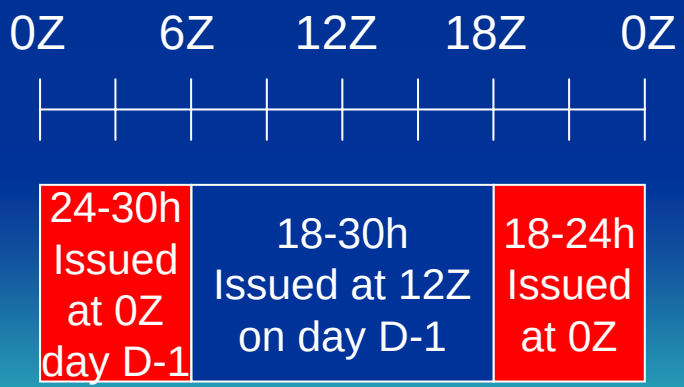
Ensemble Environmental Predictions using MEC/MESH

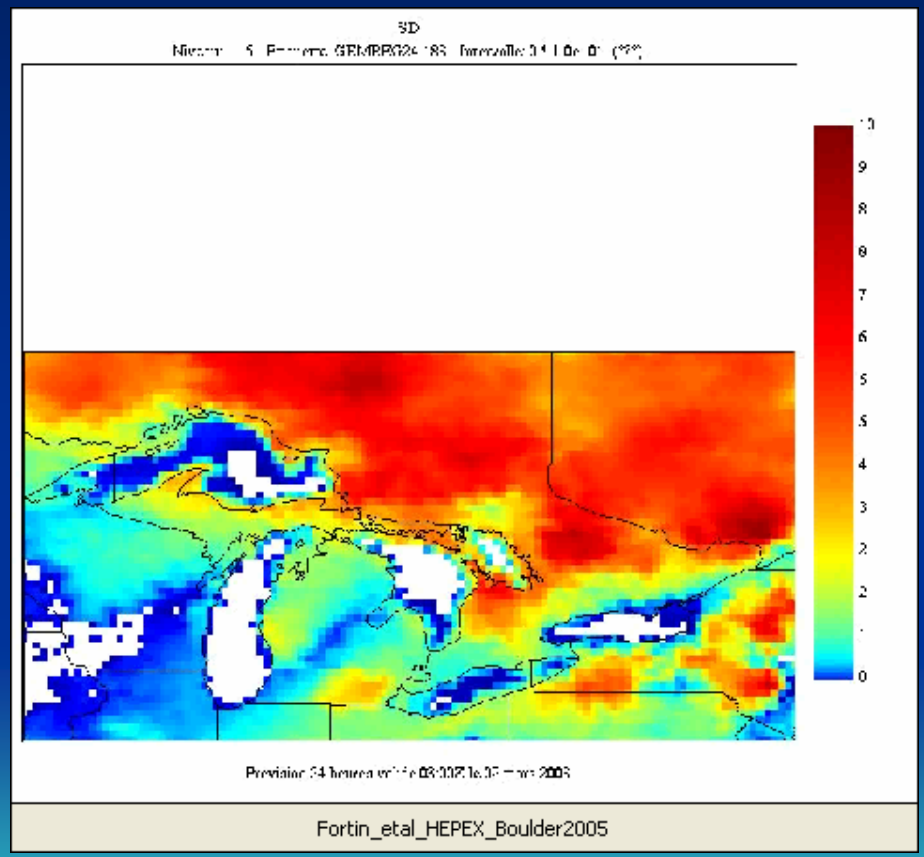
- Test case for MEC/MESH
  - St-Lawrence basin, north of Montréal, QC
    - Including all of the Great Lakes (~1M km²)
  - March-August 2003



Snowmelt simulation with MEC

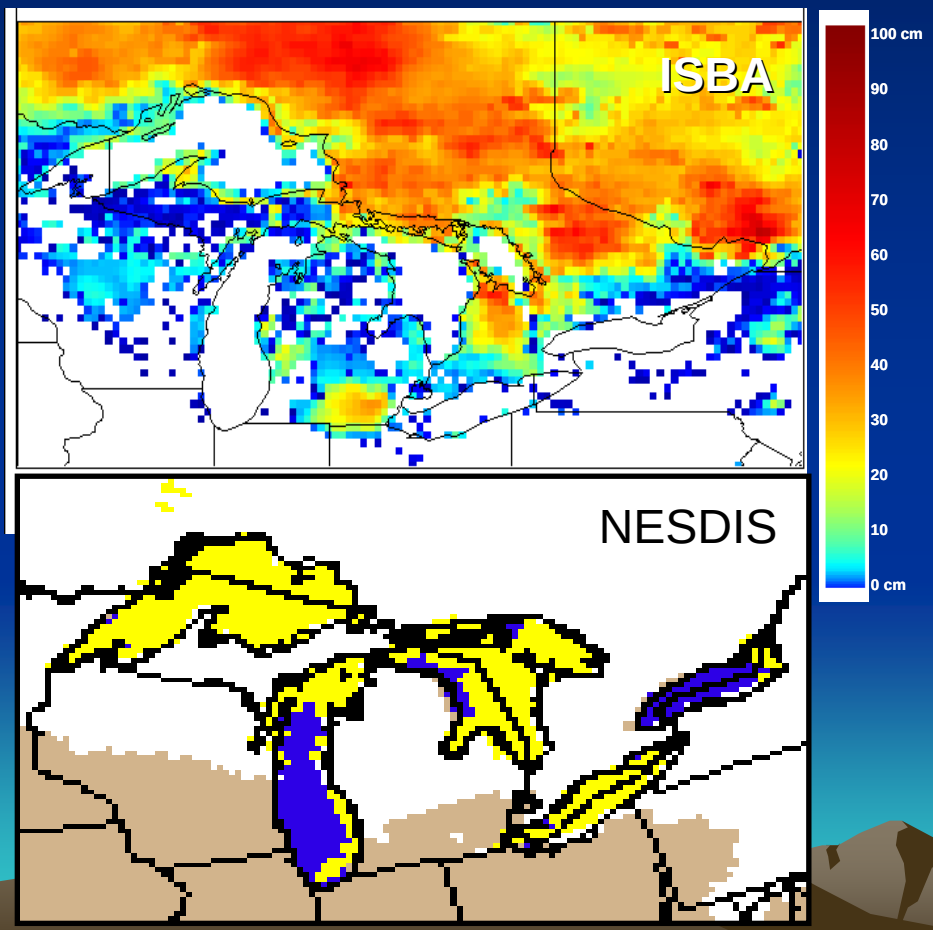
- Snow depth simulation
  - March-April, 2003
  - ISBA @ 15km
  - forced by GEM @ 24km
    - Continuous sequence of 18h-30h forecasts



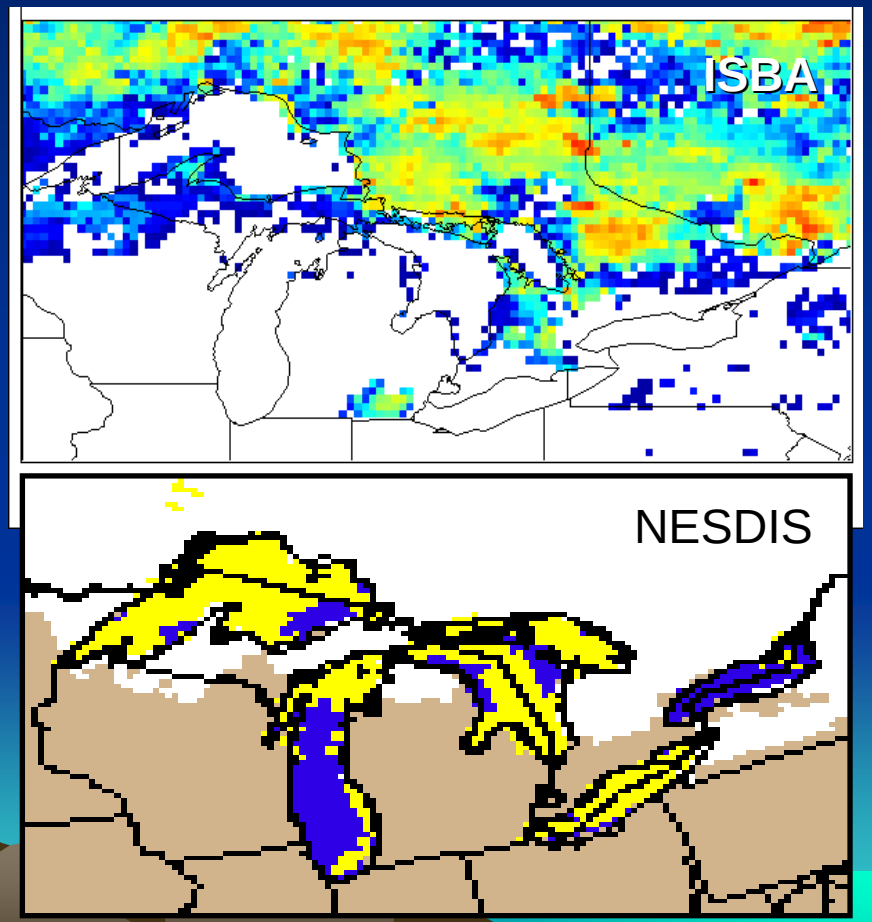


A comparison with NOAA/NESDIS snow cover analyses

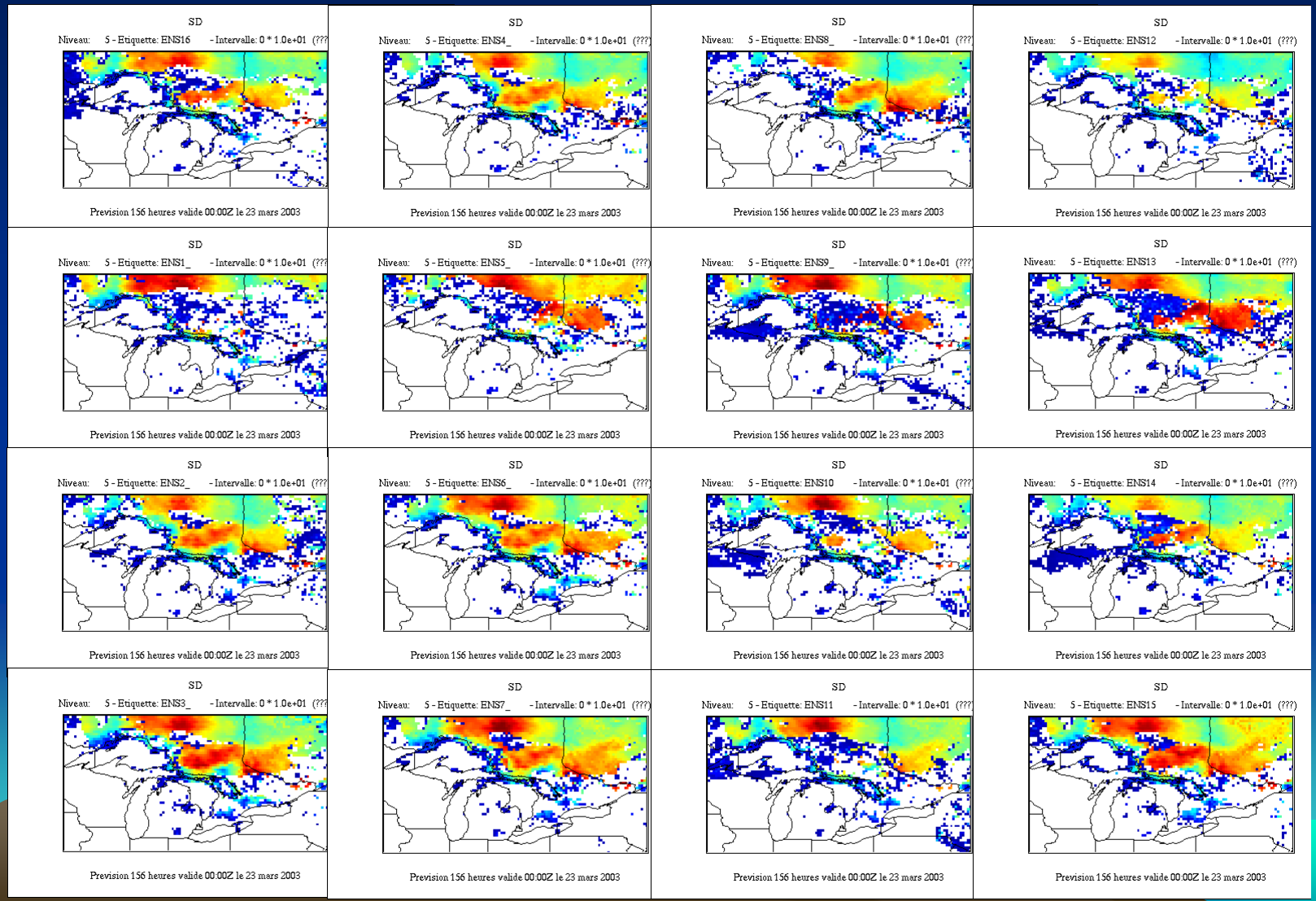
- March 16, 2003



- March 23, 2003



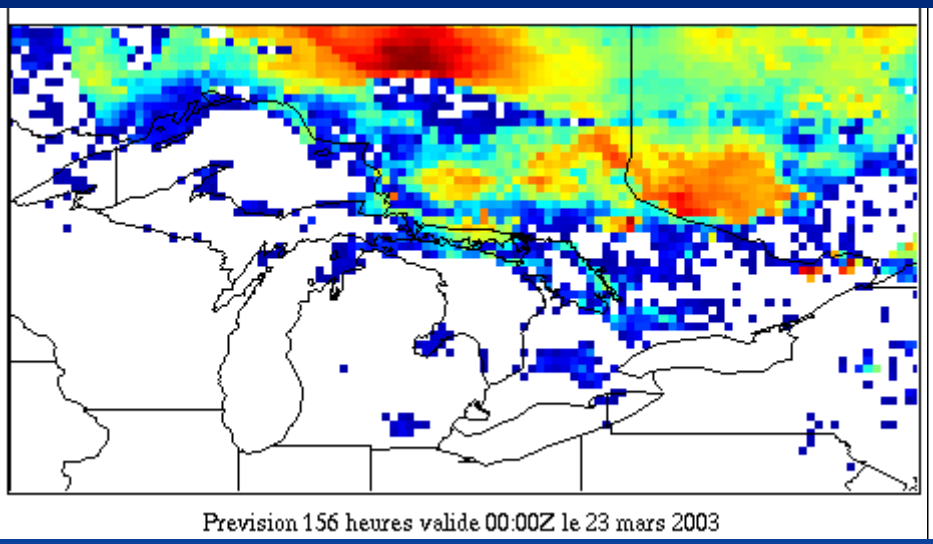
1-week ahead Ensemble forecasts of snow depth for March 23, 2003



1-week ahead Ensemble forecasts of snow depth for March 23, 2003

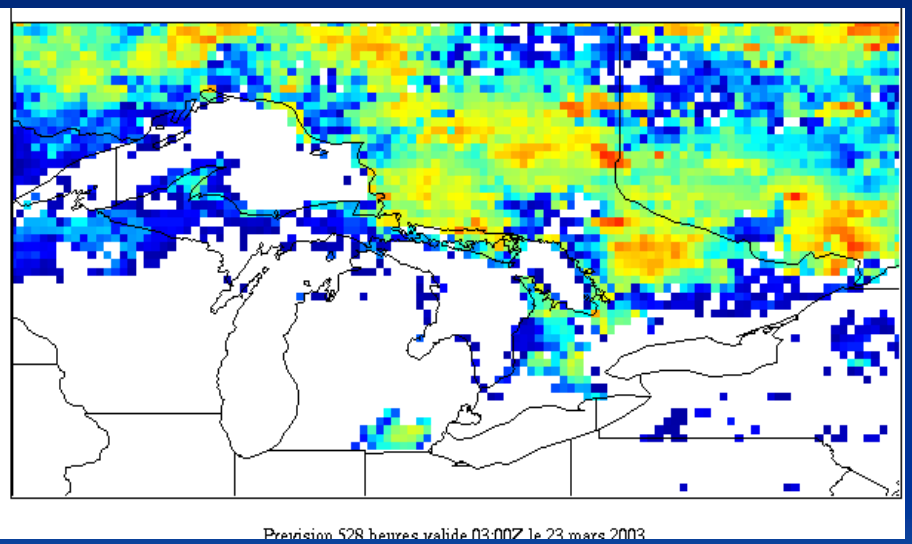
7 day-ahead forecast

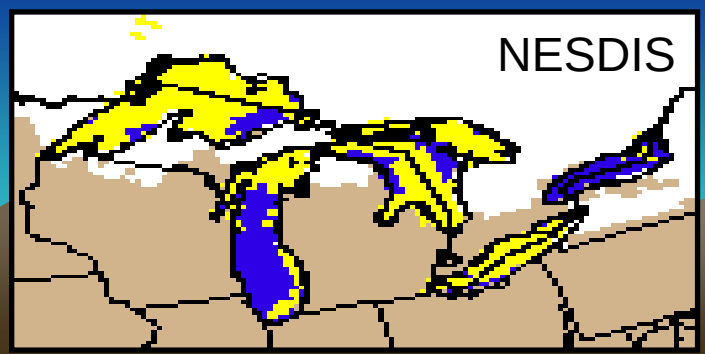
- Mean of the ensemble



Simulated snow depth

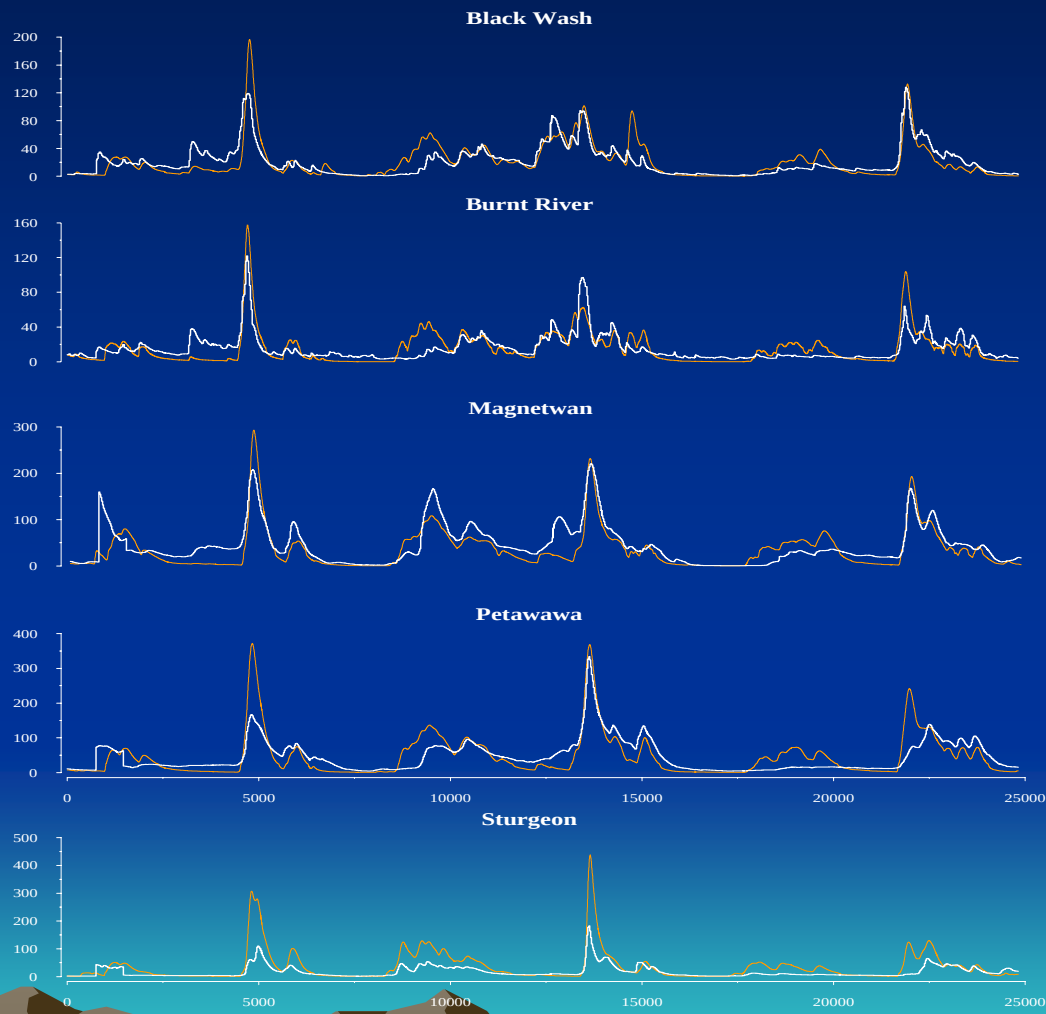
- From March 1st



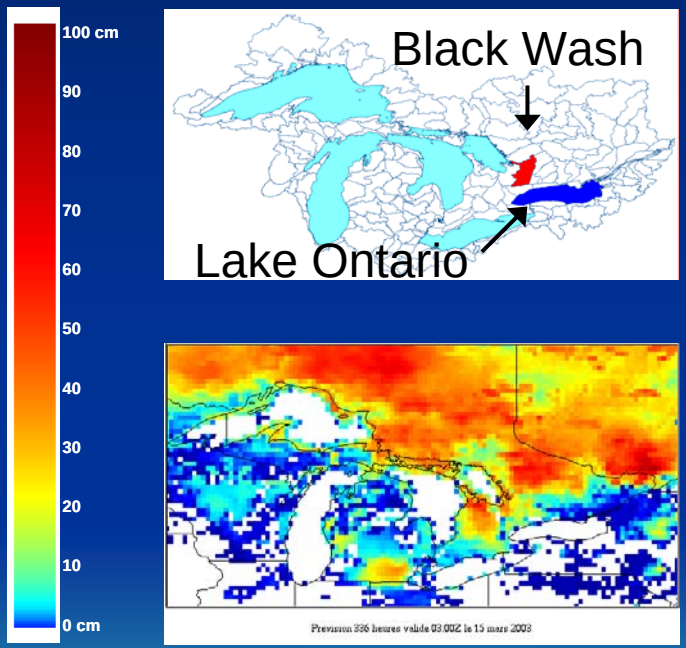


Streamflow simulations results for selected subwatersheds

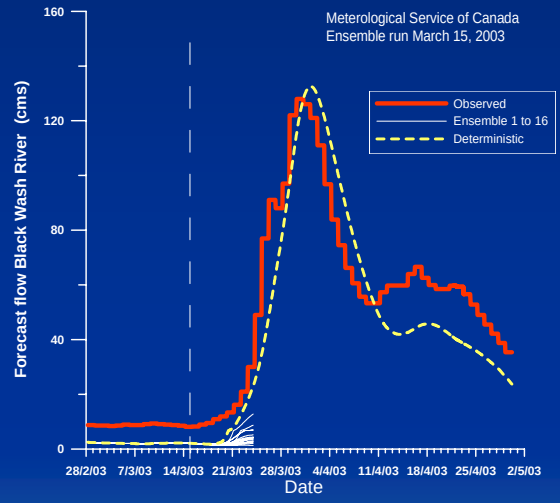
- Forced with synoptic observations of precipitation and temperature
- WATFLOOD land surface scheme



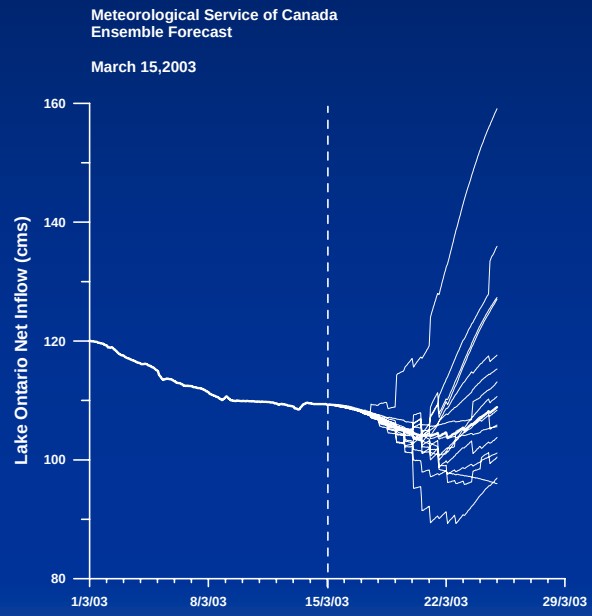
Ensemble streamflow and lake inflow forecasts – March 15, 2003



Snow depth
(as simulated by ISBA)

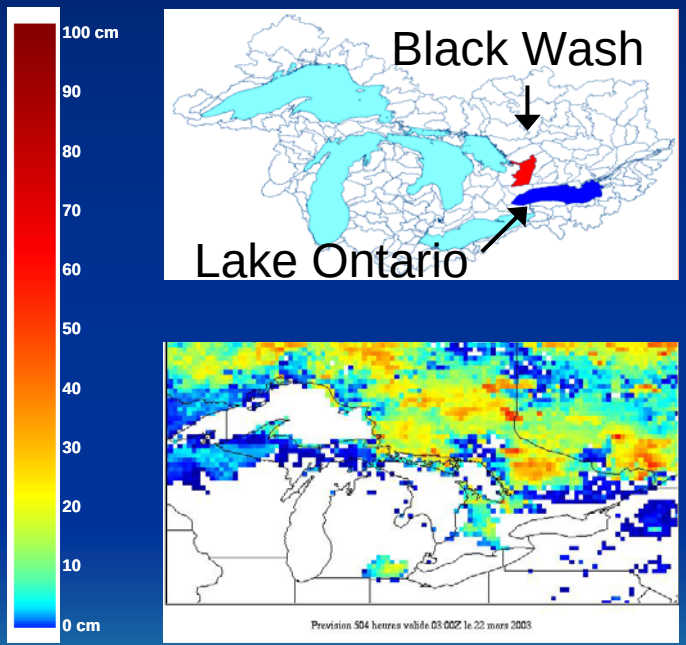


Black Wash

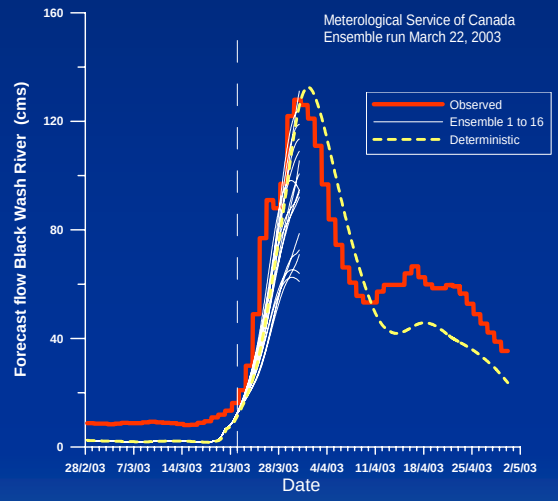


Lake Ontario

Ensemble streamflow and lake inflow forecasts – March 22, 2003



Snow depth
(as simulated by ISBA)



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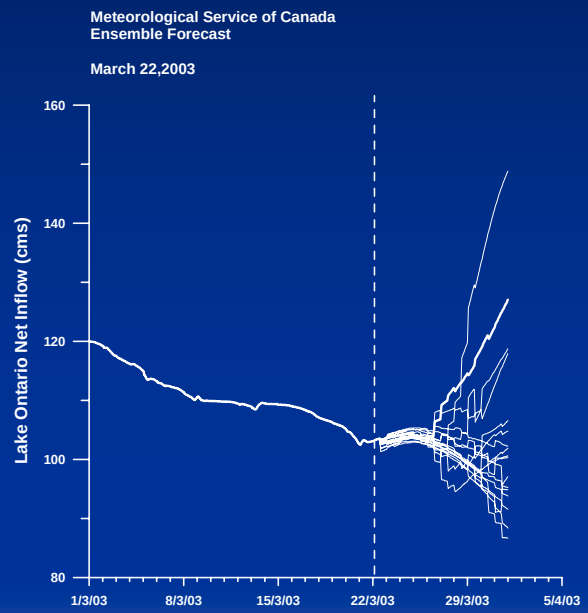
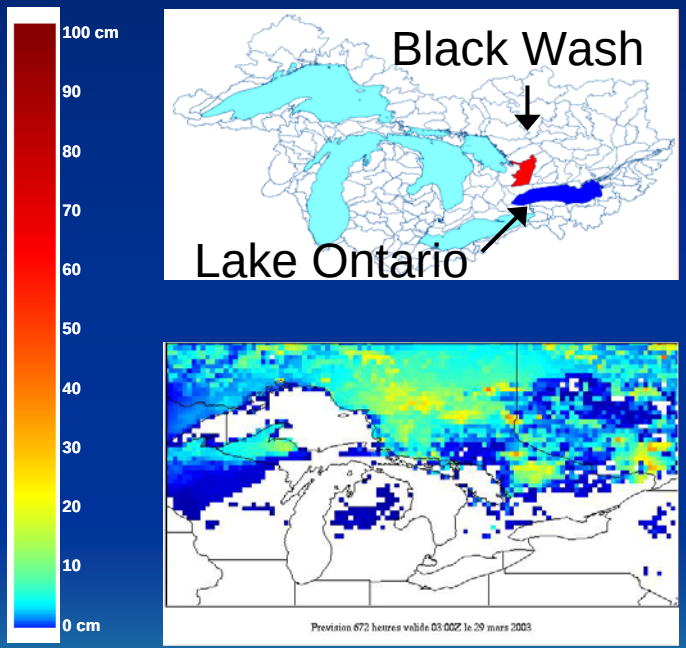
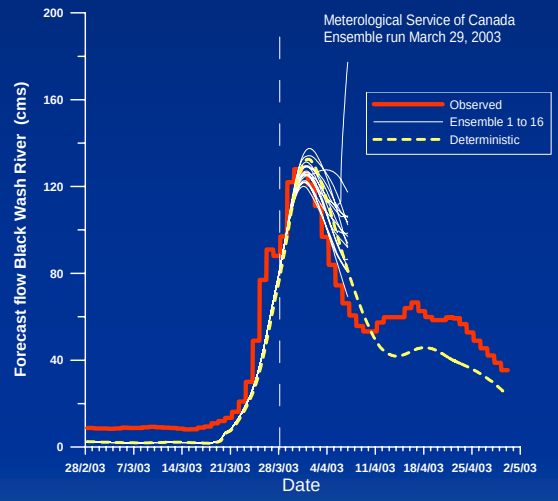


Lake Ontario

Ensemble streamflow and lake inflow forecasts – March 29, 2003



Snow depth
(as simulated by ISBA)



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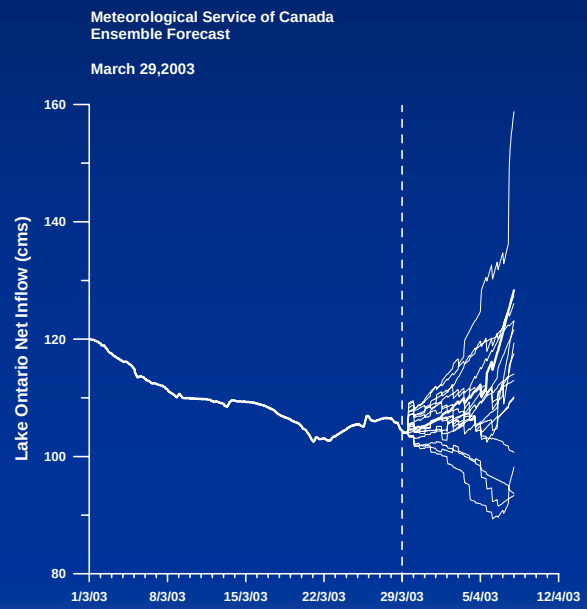
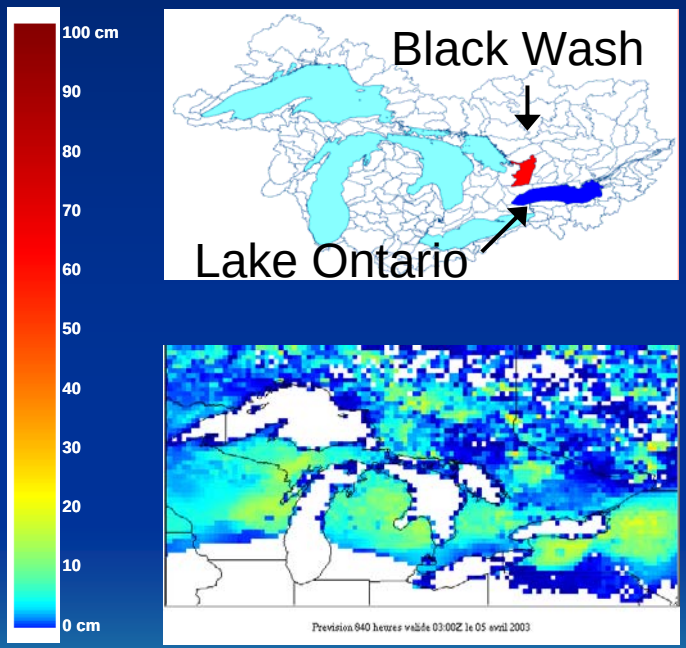
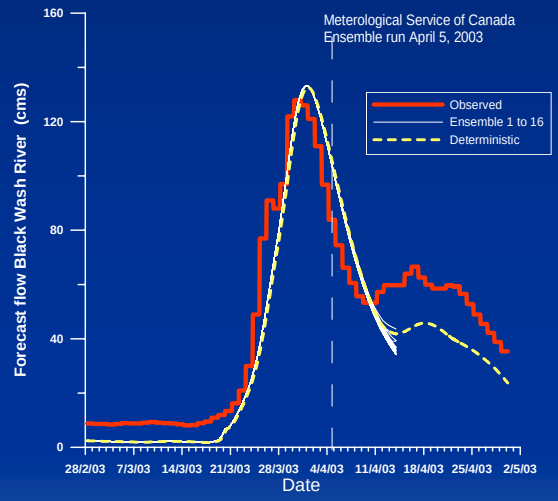


Lake Ontario

Ensemble streamflow and lake inflow forecasts – April 5, 2003



Snow depth
(as simulated by ISBA)



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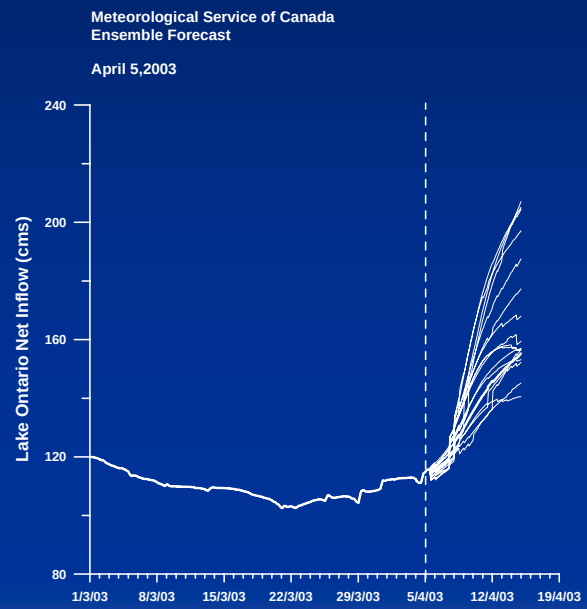
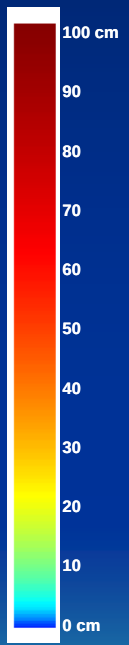
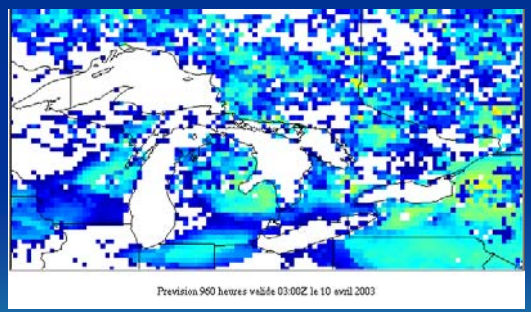


Lake Ontario

Ensemble streamflow and lake inflow forecasts – April 10, 2003





Snow depth
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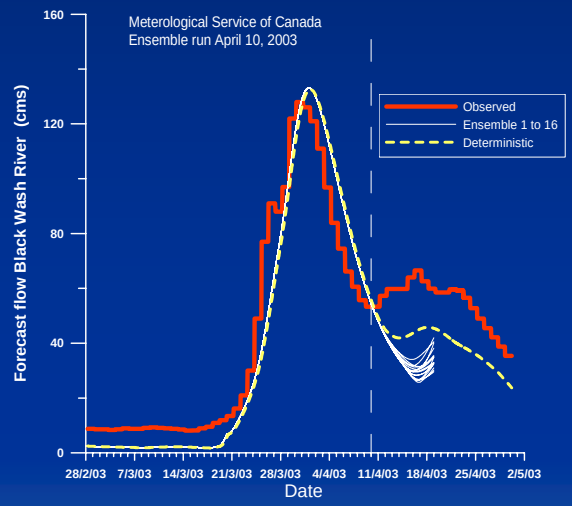

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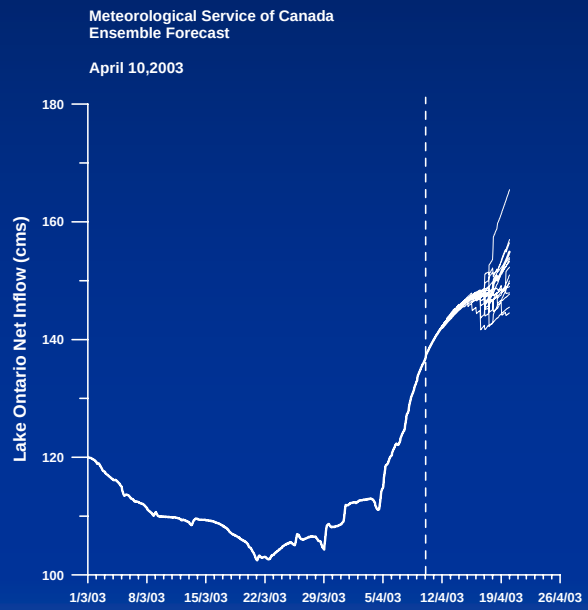

Lake Ontario

Next steps

- Pre- and post-processors needed to produce calibrated forecasts
- Linking with the NAEFS project
- Validation of MESH outputs
  - Testbed: Great Lakes Basin

Conclusions

- A Community Hydrologic Prediction System (CHPS) is essential to any collaborative effort in hydrologic ensemble prediction
  - To test scientific hypotheses and share results
  - To realize the benefits of the improved science
- Building a CHPS from scratch for regional hydrologic modelling is a formidable challenge
  - This is why we are developing a CHPS within the existing MEC system

Conclusions

- MEC is available for download:
  - As the current version of MEC is a subset of the GEM atmospheric model driver, go to:

    http://collaboration.cmc.ec.gc.ca/science/rpn.comm/
  - Then Click on « GEM »
  - Complete documentation for installing and running MEC available online