

## Environmental Numerical Prediction Research:

- *Atmosphere-Hydrology*
- *Atmosphere-Ocean-Ice*
- *Urban*

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11/24/2008

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## Plan and objectives:

Three scientific projects which allowed or will allow a direct improvement in the services offer to the Canadian community.

- To demonstrate the capacity and utility between the:
  - 1) Atmospheric and Hydrologic
  - 2) Atmospheric and Ocean-Ice
  - 3) Urban modeling

### Key partnerships:

- EC: CCCma, CRD, MSC, NWRI
- Universities: Waterloo, UQAR
- International: CERFACS, Météo-France

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Atmosphere-land-hydrology:

How:

- These models focus on the vertical water and energy budget.
- Attempt to close the water budget at a basin scale.
- Best available data and models to assess surface state variables in real time.
- ISBA and CLASS can now better represent hydrological controls on soil moisture with the addition of surface runoff, subsurface flow, and groundwater recharge parameterizations.

Why:

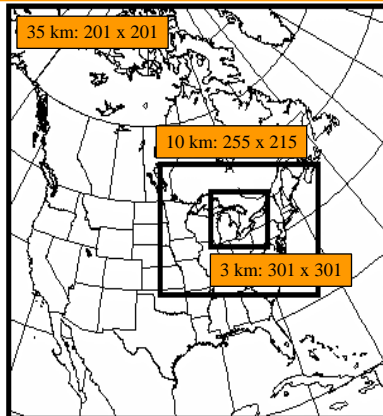
- Produce real time estimates and forecasts of surface state variables in the water cycle (soil moisture, soil temperature, snow, vegetation...).
- Provide surface fluxes to the atmospheric components (coupled).
- Allow to address water availability needs.
- New products available to the Canadian community (Hydrology, Agriculture, Great-Lakes, IJC...)

1) Atmosphere-Hydrology

- Impacts of 3 atmospheric forecasts on hydrological simulations.

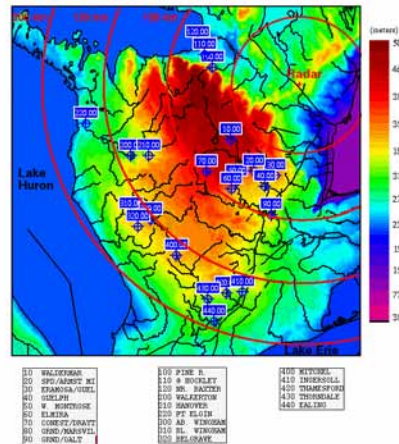
Atmospheric Model

Grids



Hydrologic Model

SW Ontario Watersheds

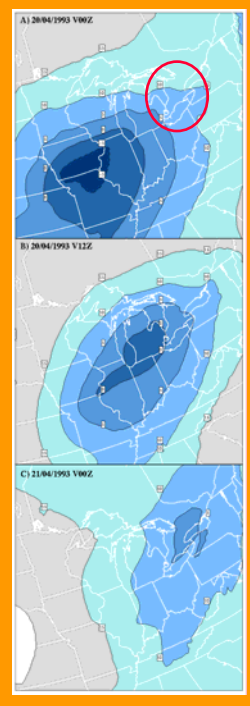


**Case: (19-20-21 April 1993)**

“The weather during the 3 days was quite varied in type and scale. To the northeast of the radar, one area reported all of snow, freezing rain, thunderstorms, hail and strong winds. During the period the precipitation was mainly stratiform but there were several convective period.”

20/04/93 12Z

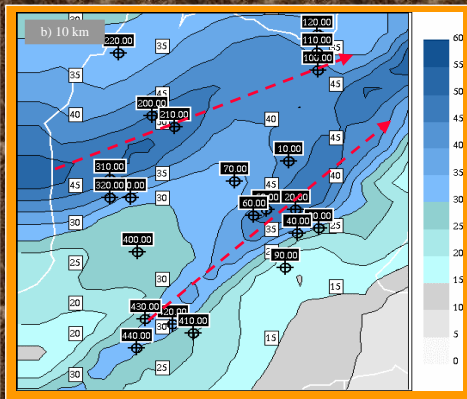
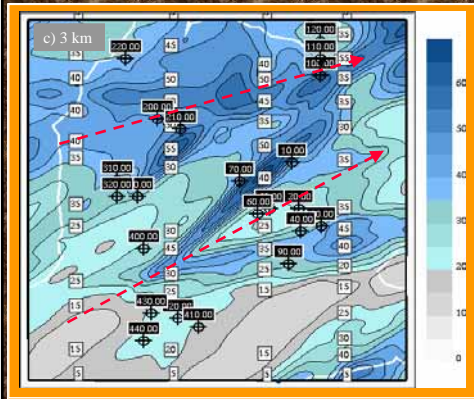
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**Precipitation Accumulation 72H**

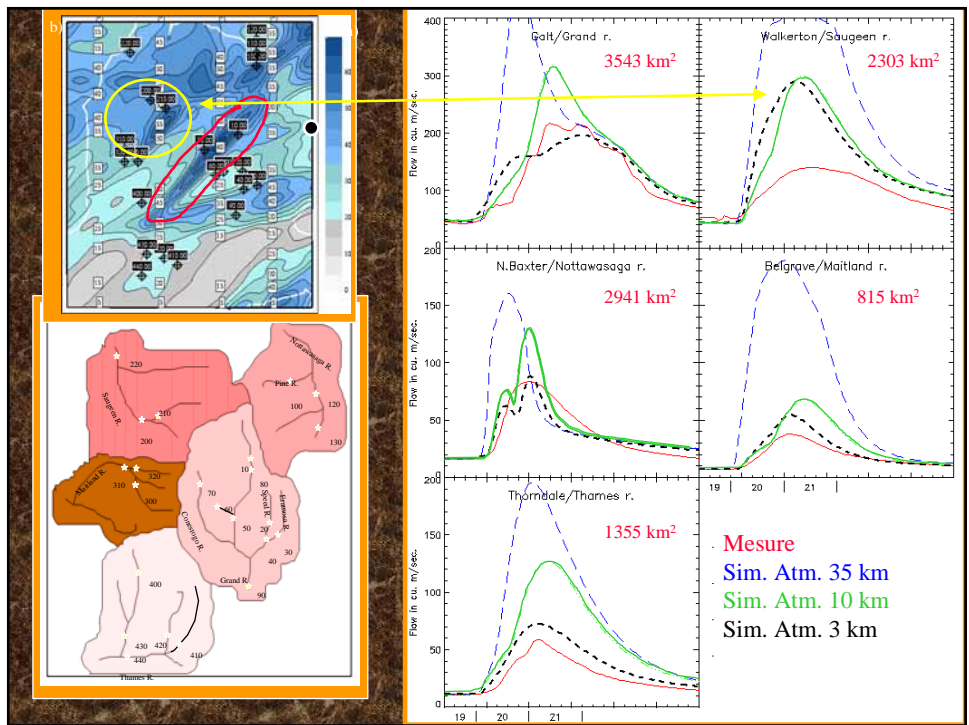
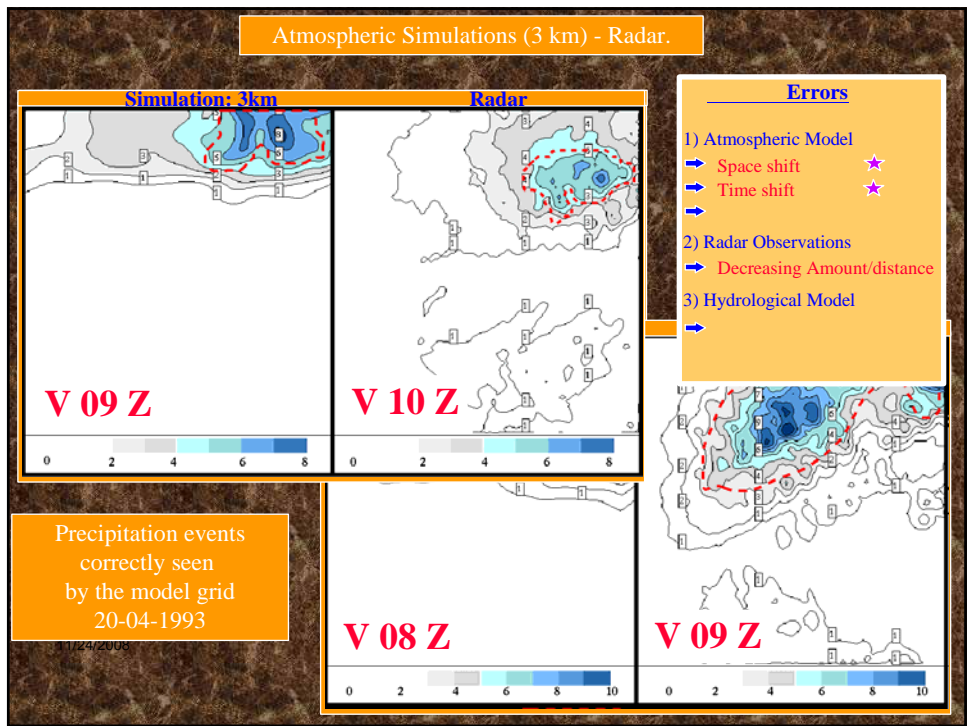


**3 km**  
Precipitation Schemes  
Conv: AUCUM  
Strat: Microphysics

**10 km**  
Precipitation Schemes  
Conv: Kain-Fritsch  
Strat: Microphysics

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**Conclusions:**

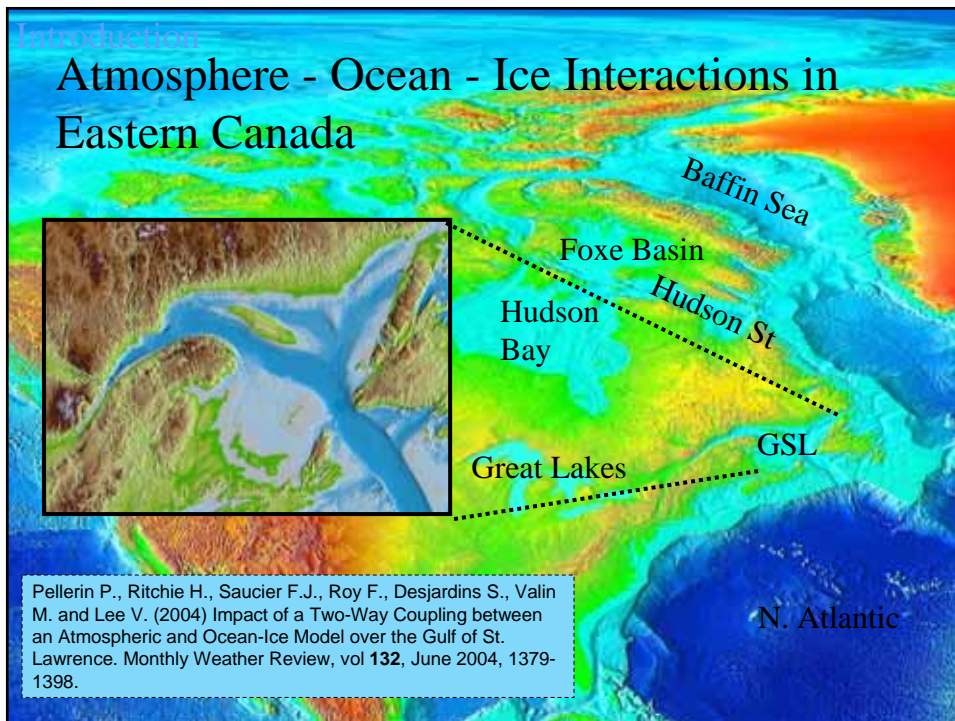
- The increase of resolution has allowed to better resolve the observed events.
- The model has the capacity to approximate the observed weather events.
  - MRD continues to improve the models and data assimilation techniques.
- The hydrological simulations, combined with hydrological observations, give essential information on the amount of precipitation and on future soil moisture conditions.
- The coupling Atmosphere-Hydrology will allow to improve the operational environmental forecasts.
- The atmospheric components are operational at the CMC and we work with NWRI, WSC on the validation of the hydrological component.



## Atmospheric-Ocean-Ice

### Why:

- Coastal weather forecasts are very affected by the ocean conditions.
- During the ice period, both systems are particularly interdependent.
- To improve the atmospheric forecasts (icing, clouds, fog,...)
- To improve the ocean-ice forecasts (ice, currents, temperature, waves...)
- To improve the services:
- Users: EC, coast-guard, DFO, maritime transportation



## Methodology

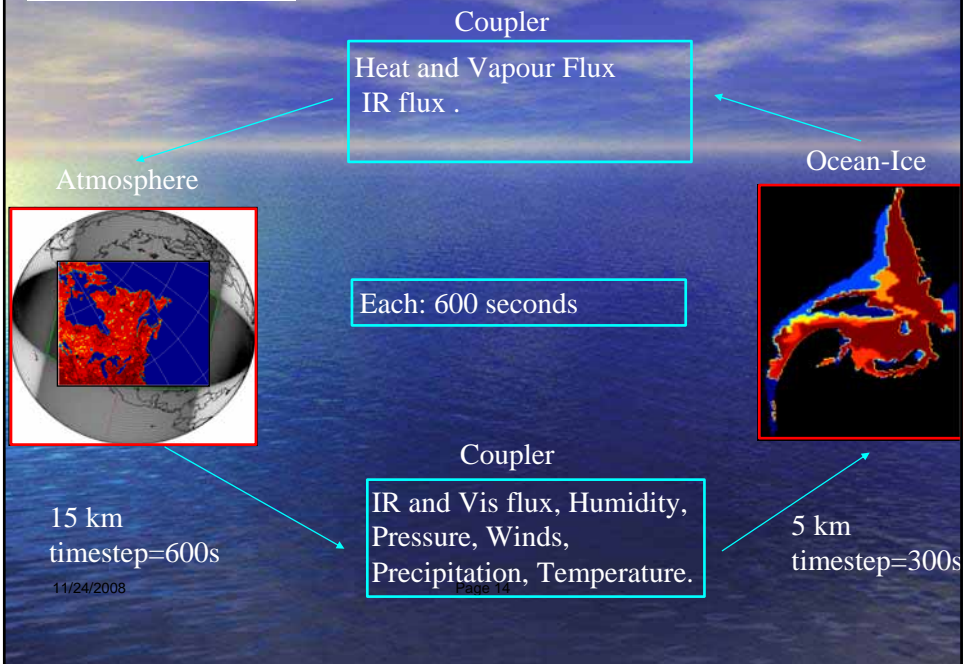
# Models & Coupler

- Global Environmental Multi-scale (GEM, Côté et al. 1998):
  - Regional configuration LAM @ 15km and 58 levels;
  - Dynamic 3.2.2+, physics 4.0+;
- Gulf of St. Lawrence Model (ROM, Saucier et al. 2003):
  - 3D Ocean @ 5km and 73 levels; version 4.9.5 (5.2.2);
  - Sea-ice (dynamic - thermodynamic);
    - Elastic-viscous-plastic (EVP) model (Hunke & Dukowicz, Los Alamos CICE model, 1997);
    - Thermodynamic: Semtner, 1976;
- OASISv3-Gossip (Valcke 2004)

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## Coupling description

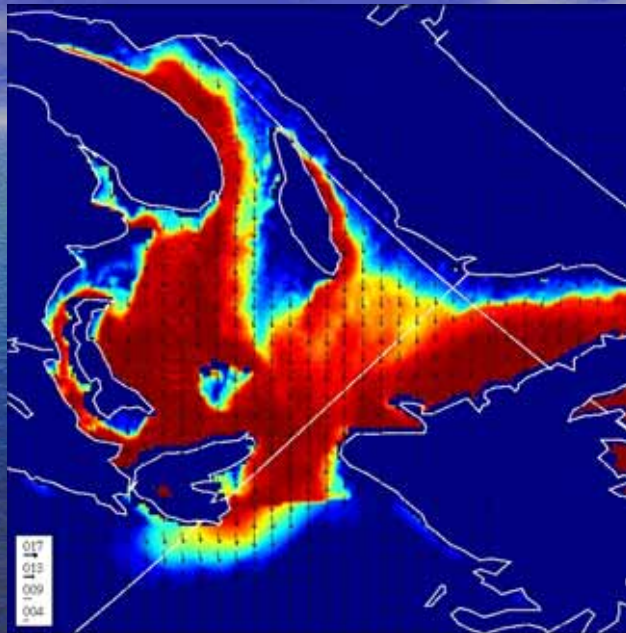


Atmospheric-Ocean-Ice

Ice fraction on the  
4 km atmos. grid  
48h forecast  
2 way coupling

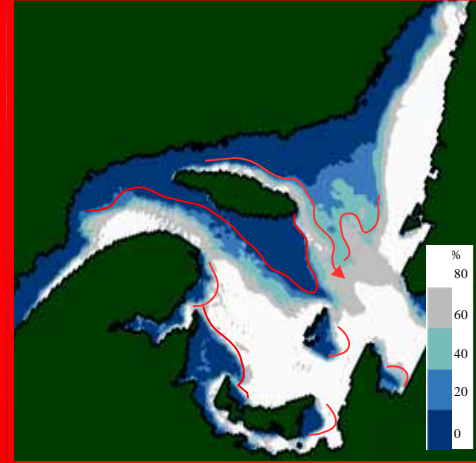
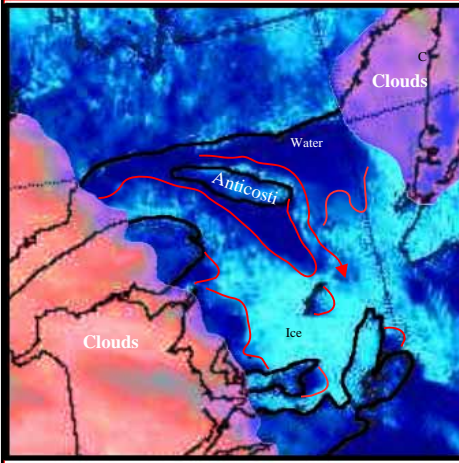
Case: Particularly interesting given that the intense atmospheric circulation that dramatically changed the Ice conditions in only 48 hours was preceded by a cold and relatively quiet period.

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Ice Observation

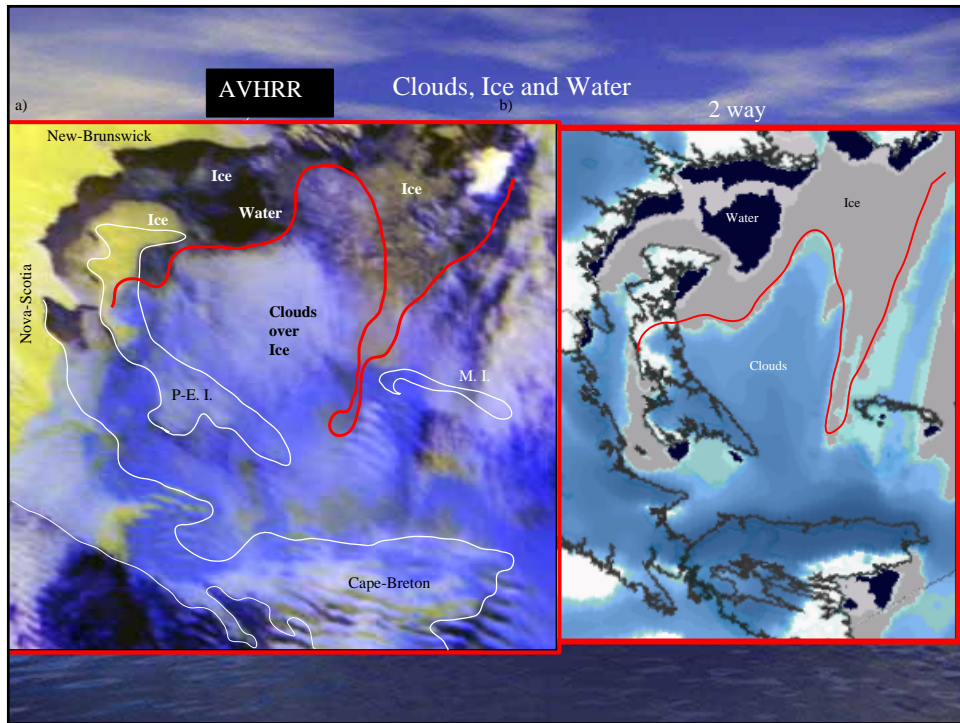
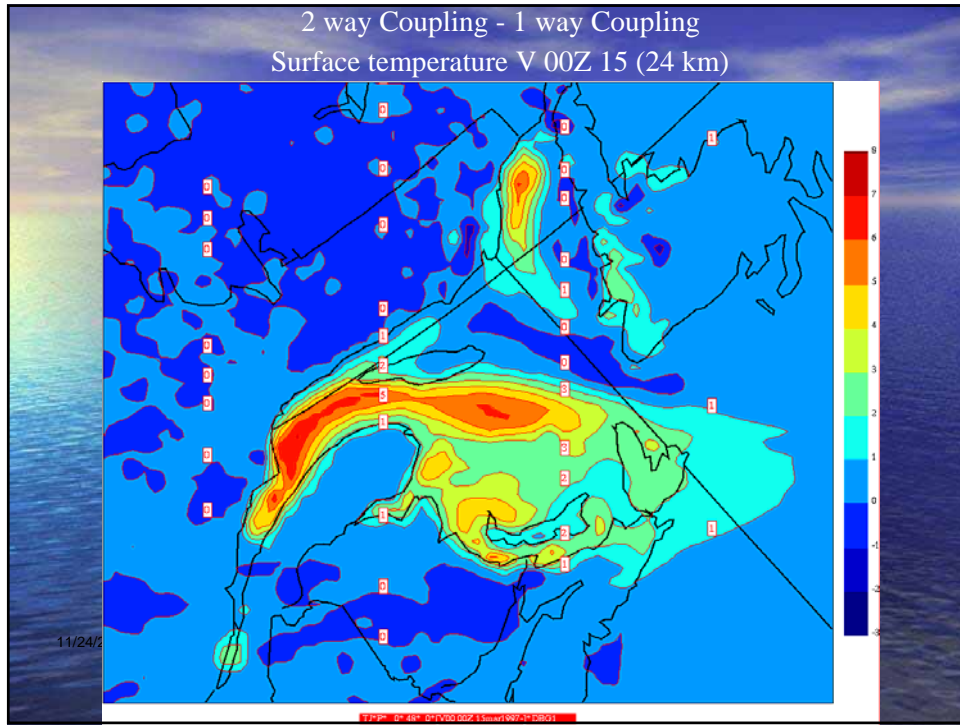
Forecast (2-way) Ice



Valid: 14/03/97 20 Z after 44 hours

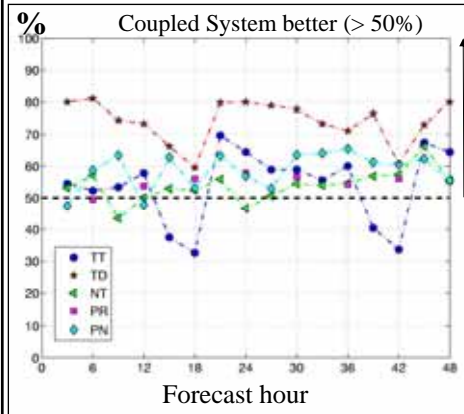
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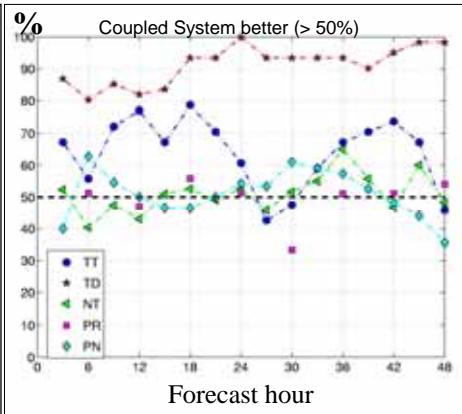


# Experimental Operational System at CMC

## Winter



## Summer



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Environnement  
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### Conclusions:

- The coupled system seems to produce very good results.
- The fully interactive coupling allows to improve:
  - Ice forecasts
  - Clouds (best fluxes)
  - Temperatures
  - Precipitations
  - Surface pressure
- Has been transferred to CMC development and operations
- S&T continues (with DFO) to work on the physical processes (fluxes).

### Benefits:

- Strong Collaboration between EC-DFO-Coast Guard-Universities
- This expertise is or will be used:
  - to develop the global atmosphere-ocean system (Mercator project)
  - to develop a similar system for Great-lakes and Hudson bay
  - to develop a coupled Atmospheric-Ice system for the Arctic
- Better services delivered by the departments.

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## Towards an Operational Urban Modeling System for CBRN Emergency Response and Preparedness

### Objectives of the main project:

- To respond effectively to an attack, rapid decisions need to be made concerning the transport, dispersion, deposition and fate of the CBRN agent and its concomitant effects on the exposed population.
  - Development of a prototype for Environmental Emergency Response
  - Multi-scale CBRN Hazard Prediction Model for the Urban Environment
  - To provide decision making framework to minimize consequences injuries, casualties, and contamination
- Improve the representation of cities in Canadian meteorological models:
- Project partners:
- R&D Defence Canada, AECL
  - Universities of Waterloo and Calgary
  - CFD models at street- and building-scales



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## Microscale Modeling project:

### Purpose:

- To test the feasibility of adapting an atmospheric model code into an urban model code, producing a single code that is valid for both. A Unified Dynamical Model for Atmospheric and Urban modeling. (**fully compressible, non-hydrostatic, terrain following coordinate, solid objects, turbulence 3D, TEB,**).
- 1 model with thermodynamic and dynamical effects.
- To improve the coupling between atmospheric and CFD models.
  - Better representation of the dynamical effects (drag, building) in the atmospheric model.
  - Better initial and boundary conditions for the CFD model.

### Motivation

- Share scientific expertise with CFD community.
- Identify approach for GEM or other future models (emergencies and air quality).
- The dynamical kernel of the Canadian atmospheric model is very sophisticated (without main approximations) allowing to run at very high resolutions.

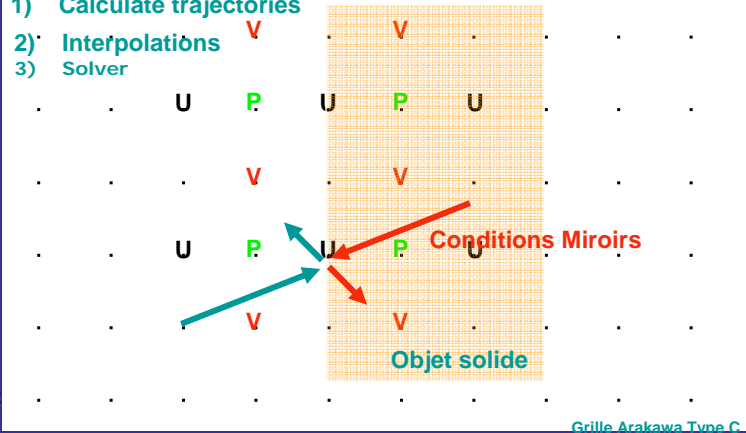
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## The Solid objects

Actions:

- 1) Calculate trajectories
- 2) Interpolations
- 3) Solver



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Grille Arakawa Type C

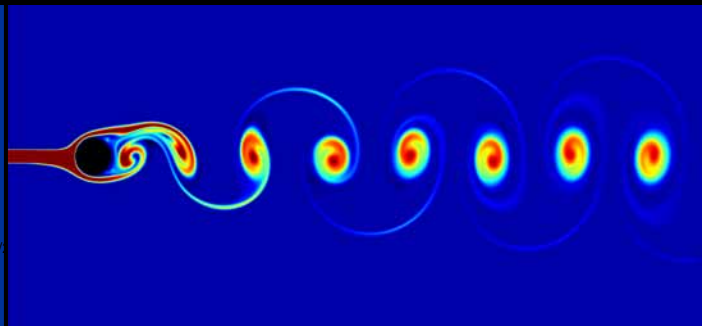
### Solid Objects: Von Karman Vortex Streets



*Laboratory  
Experiment  
Re=140  
Cylinder*



- Small amount of Numerical noise => Allow to produce realistic vortex
- Small amount of Numerical diffusion => Allow to maintain the vortex



*Numerical  
Experiment  
Atmospheric  
Model  
Re=140  
Cylinder*

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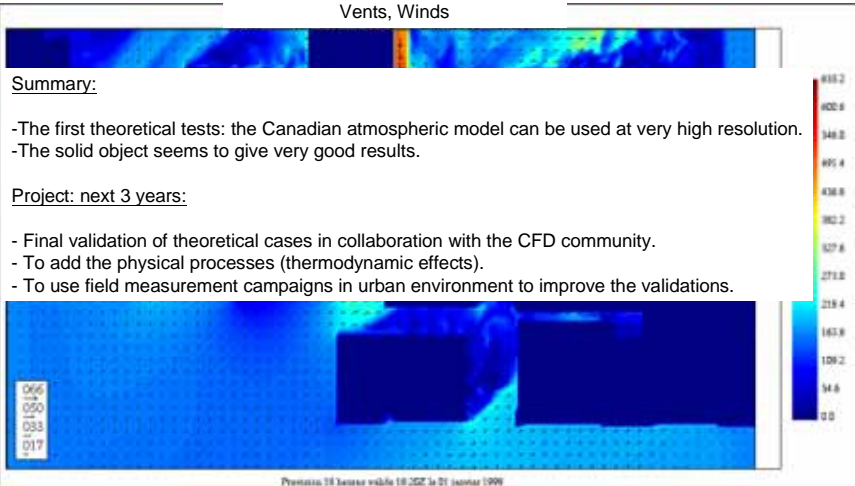


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Demonstration experiment: (Oklahoma city)  
(300 x 200 x 50), DX=DY=1.5 meters, Dt=0.12 sec,  
Vents, Winds



Summary:

- The first theoretical tests: the Canadian atmospheric model can be used at very high resolution.
- The solid object seems to give very good results.

Project: next 3 years:

- Final validation of theoretical cases in collaboration with the CFD community.
- To add the physical processes (thermodynamic effects).
- To use field measurement campaigns in urban environment to improve the validations.

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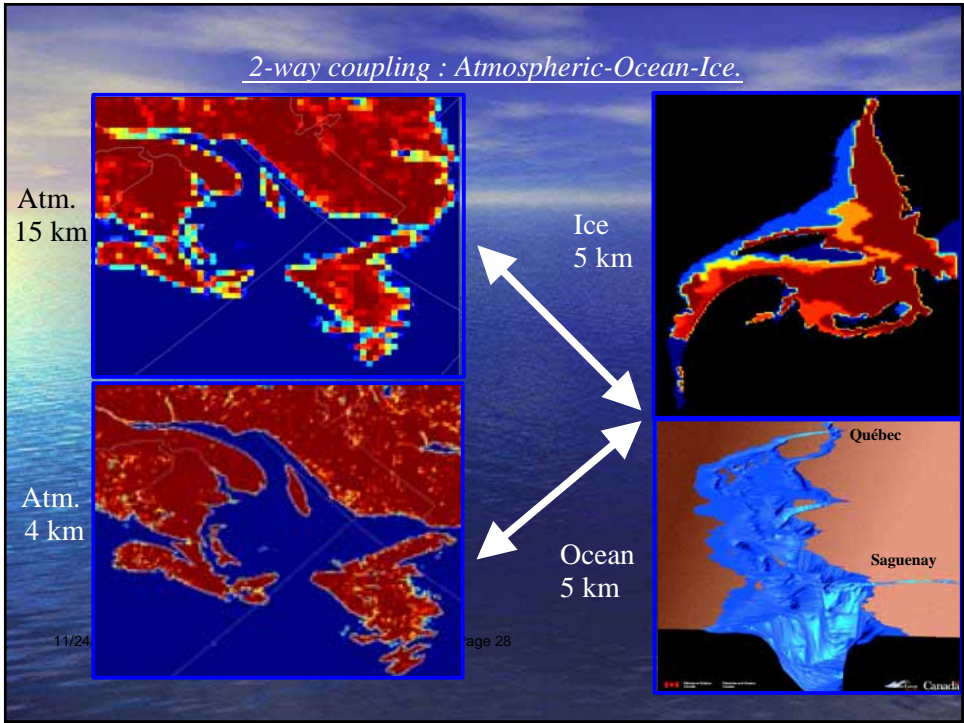
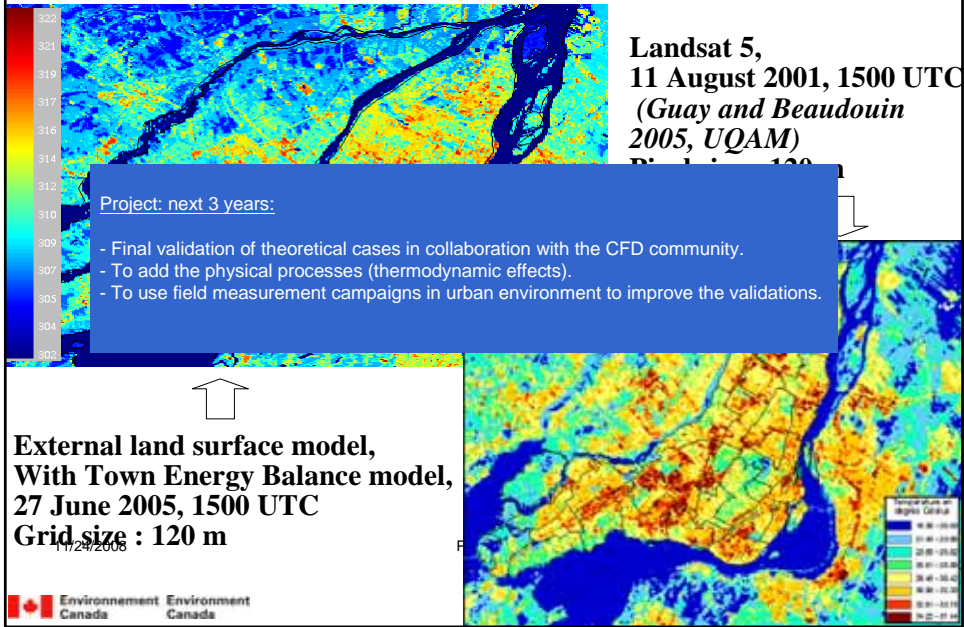
**Conclusion:**

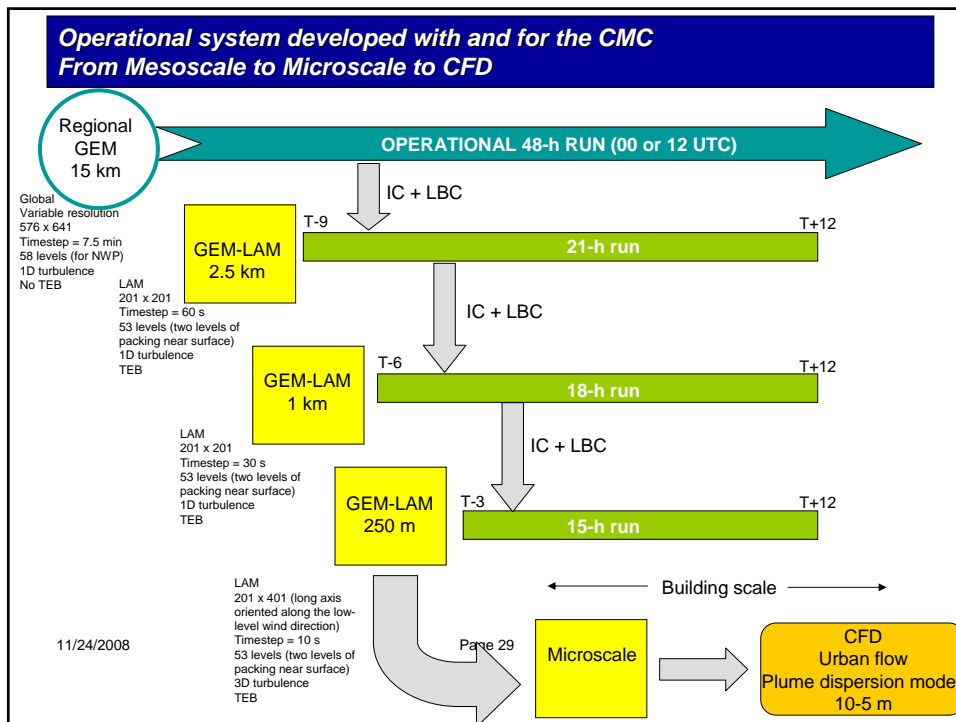
- The Environmental modelling is essential to improve the Canadian Atmospheric forecasts.
- We now have the scientific and technical capabilities to build comprehensive environmental prediction systems integrating expertise from a wide range of disciplines and addressing important R&D and operational issues (hydrology, Ocean-Ice, Lakes, soil, snow, vegetation, ecosystem...).
- **Develop the capability to understand past, current and future water balances resulting from weather-climate variability and human activity;**

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**HIGH-RESOLUTION OFFLINE MODELING of  
URBAN HEAT ISLANDS – RADIATIVE SURFACE TEMPERATURES**





**Canadian Numerical Modelling For Environmental Prediction  
Système - MEC – System  
(Modelling Environmental Community System)  
(Modélisation Environnementale Communautaire)**

**A collaborative effort between:**

- SMC-MSC
- DFO-MPO
- DND
- NHRC Saskatoon
- Canadian Space Agency
- Canadian Universities
- Canadian Companies
- Provinces
- Countries

**For:**

- Atmospheric Models
- Chemistry Models
- Environmental Emergency Models
- Ocean Models
- Ice Models
- Waves Models
- Land-vegetation Models
- Hydrological Models
- Hydrodynamic Models
- Ecosystem Models

Partnerships/collaborations based on joint investment for mutual benefits