Plans for Coupling and Coupled Data Assimilation in GOAPP, and Interactions with Mercator and CONCEPTS

Hal Ritchie and Many Colleagues

October 23, 2007

Outline

- Report on Mercator meeting October 15-18, including update on CONCEPTS and proposed Canada-Mercator activities
- Plans for coupled atmosphere-ocean data assimilation in GOAPP

Environment Canada Environnement Canada

Canada

Proposed Canada-Mercator Activities

Hal Ritchie, Pierre Pellerin and many colleagues

Meteorological Research Division

16 October 2007

Outline

- Update on the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS)
- Canadian Investments in CONCEPTS
- Resources in the Global Ocean-Atmosphere Prediction and Predictability (GOAPP) Network
- Progress in related projects
- Objectives for this meeting

Update on CONCEPTS

- Substantial scientific resources are being oriented towards the improvement of the Mercator system as a mutually beneficial Franco-Canadian partnership
- The ocean system is being coupled with Environment Canada (EC) atmosphere and ice data assimilation and prediction capabilities in a coupled atmosphere-ocean-ice system for improved forecasts
- Fisheries and Oceans Canada (DFO) regional and global modelling expertise is focused on validating and improving the ocean component and developing related ocean products
- Many of these products are of special interest to the Department of National Defence (DND)

Initiating an Operational Canadian Global Assimilation and Prediction Capability for the Coupled Atmosphere-Ocean-Ice System

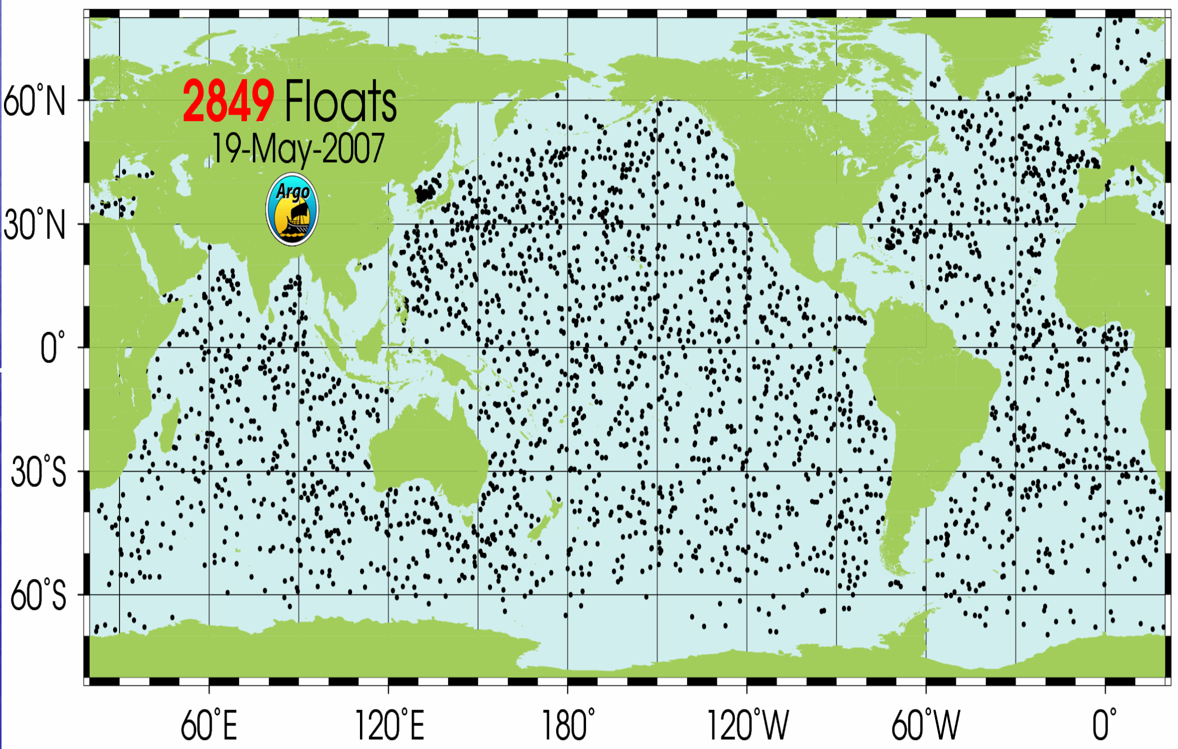
Harold Ritchie [1], Fraser Davidson [2], John Loder [3],
Youyu Lu [1] , Pierre Pellerin [1] , Wayne Renaud [4] ,
Keith Thompson [5] and Dan Wright [3]

[1]Meteorological Research Division, EC
[2]Northwest Atlantic Fisheries Centre, DFO
[3] Bedford Institute of Oceanography, DFO
[4] Directorate of Meteorology and Oceanography, DND
[5] Bedford Institute of Oceanography, DFO
[5] Dalhousie University, Halifax NS

Introduction

- An initiative to establish an operational Canadian global coupled atmosphere-ocean-ice assimilation and modelling system
- To take advantage of improvements in ocean models and the new, real time global oceanographic data sets in order to
  - produce new ocean products
  - improve weather and climate predictions

new ocean data streams such as Argo



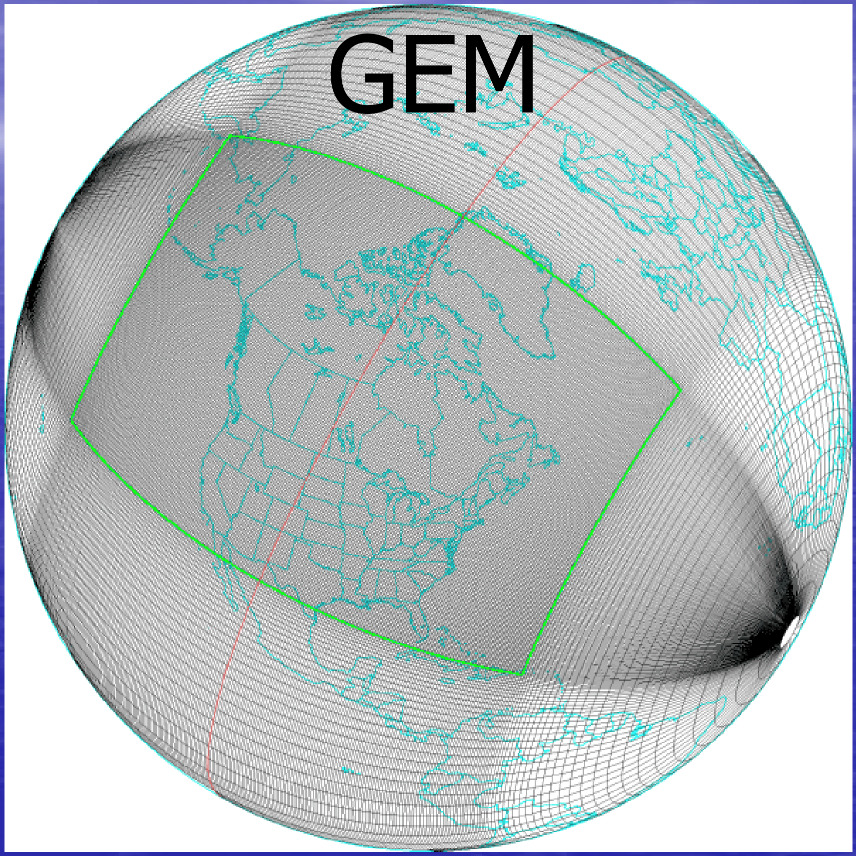
Summary of needs to be met

- Environment Canada's (EC) operational atmospheric data assimilation (4D-var) and forecast (GEM model) system at the Canadian Meteorological Centre (CMC) needs to be coupled to ocean and ice models to improve forecasting skill in some areas. Analyses will also benefit seasonal to interannual climate forecasts.
- Many Department of Fisheries and Oceans (DFO) and Department of National Defence (DND) applications will benefit from improved oceanic and meteorological information.

Weather Forecasting

The Meterological Service of Canada already has a world class weather prediction model, GEM (The Global Environmental Multi-scale Model).

However, the state-or-the-art continues to advance and we must keep up to provide maximum socio-economic benefits.



Improved ocean information is needed, Particularly for extended range forecasts

Interdepartmental planning

- For cost effectiveness, EC, DFO and DND are collaborating on this major initiative.
- After more than four years of planning by an inter-departmental panel we have initiated the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS)

Recent developments

- Endorsement of initial report by departments
- Panel has produced an implementation plan, building on initial report with additional input from sub-group of experts
- Research and development network (Thompson/Ritchie) on "Prediction and Predictability of the Global Atmosphere-Ocean System from Days to Decades" funded by Canadian Foundation for Climate and Atmospheric Sciences (CFCAS, academic funds 16 PIs for 4 years), started October 2006

CFCAS Network: Prediction and Predictability of the Global Atmosphere-Ocean System from Days to Decades (R&D)

Hours to Months (NEMO-GEM)

- Weather focus (O&A)
- Prediction & predictability
- Basin and global ocean models; global atmos
- Strong DA component
- Reanalysis
- Analysis & interpretation
- Model improvements

Months To Decades (CCCma)

Climate focus

- Prediction & predictability
- Global, coupled ocean-atmosphere
- Reanalysis
- Analysis and interpretation
- Model improvements

Coupled modelling, Validation, Analysis

Seasonal overlap

Data Assimilation, Initial Conditions, Analysis

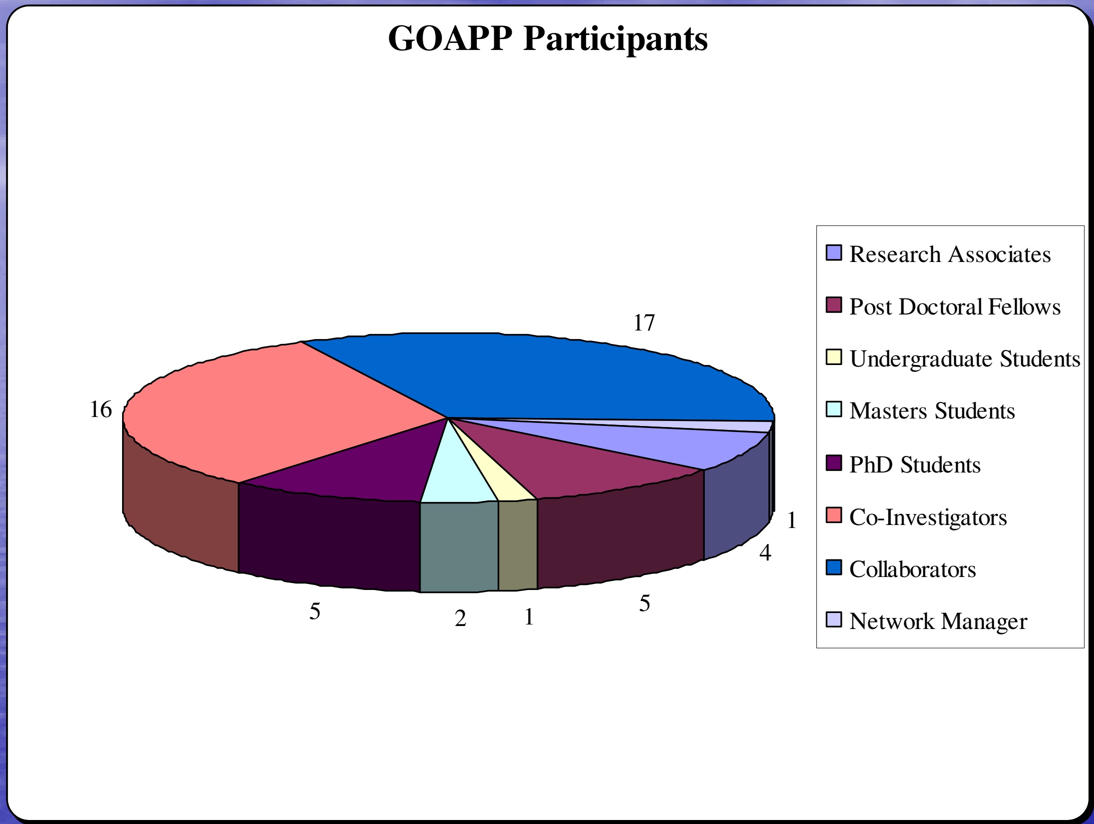
CONCEPTS Implementation Plan

- Three-Track approach :
- Operational: with a "fast start" provided by importing the Mercator ocean data assimilation and modelling system and coupling it with GEM
- Research and development: consisting of long-term government research and complementary academic research networks
- Products: to identify, develop and disseminate relevant products & outputs

Canadian Investments in CONCEPTS

- EC : Beaudoin, Bélanger, Buehner, Caya, Chamberland, Desjardins, Faucher, Flato, Lu, Pellerin, Ritchie, Roy, Computer Scientist, Ice RES, Canadian Ice Service, $500k/yr computing
- DFO: Davidson, Foreman, Hannah, Lefaivre, Loder, Ratsimandresy, Taillefer, Topliss, Wright, $500k/yr computing
- Estimated total value: $2,700k/yr (and increasing)

CFCAS Network Resources



- Academic funding $2.8 M over 4 years
- In-kind (EC, DFO, DND) ~ $975 k/yr

Proposed Canada-Mercator activities

- Core CMC systems installation, coupling and support
- Basin-to-global ocean analyses for prediction and validation studies
- Demonstration of regional ocean prediction capability and applications
- Sea ice modelling and data assimilation
- Improved ocean data assimilation capabilities

Related Canadian contributions

- Implementation of NEMO global system at EC – first reproducing Mercator configuration (ECMWF forcing), then with GEM forcing (EC) (2-member ensemble)
- Increased near real-time Canadian monitoring (IGOSS) profiles (e.g. AZMP) to Coriolis for assimilaiton by Mercator (DFO)
- Validation of Mercator nowcasts/forecasts in Canadian waters (DFO for ocean, EC for ice)
- Downscaling of Mercator nowcasts/forecasts to Canadian waters (C-NOOFS, DFO)

Current Canadian NEMO Modellers

- **Global and basins**

Dan Wright, Zeliang Wang, Fred Dupont, Jie Su,…

Youyu Lu, Jean-Marc Belanger, Francois Roy, …

Entcho Demirov, Yimin Liu, Youming Tang,…

Mike Stacey,Tsuyoshi Wakamatsu, …

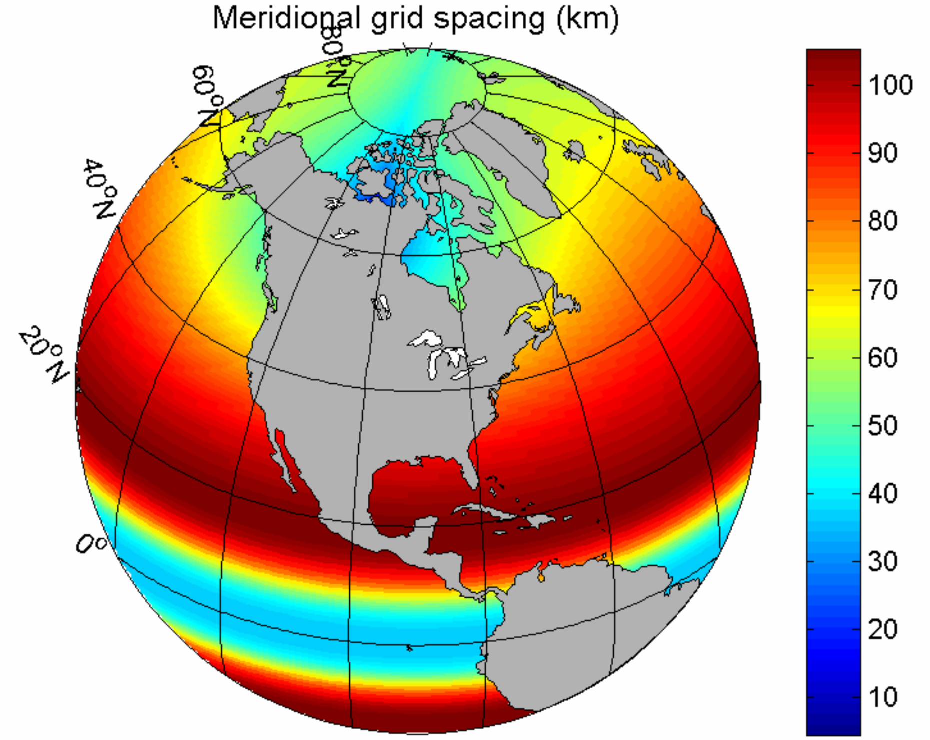
- **Shelf/coastal**

Dave Brickman, Fraser Davidson, Andry Ratsimandresy, Paul Myers…

Global Configurations

➢**Coarse resolution ORCA1:** tri-polar, nominal 1-deg grids, enhanced meridional resolution in tropics, consistent with UK SOC's setup, 46 (and 64) vertical levels

➢**High resolution ORCA02** tri-polar, nominal ¼-deg grid consistent with Mercator-Ocean's setup, 50 (or 46) vertical levels with 1m (or 6m) resolution near surface

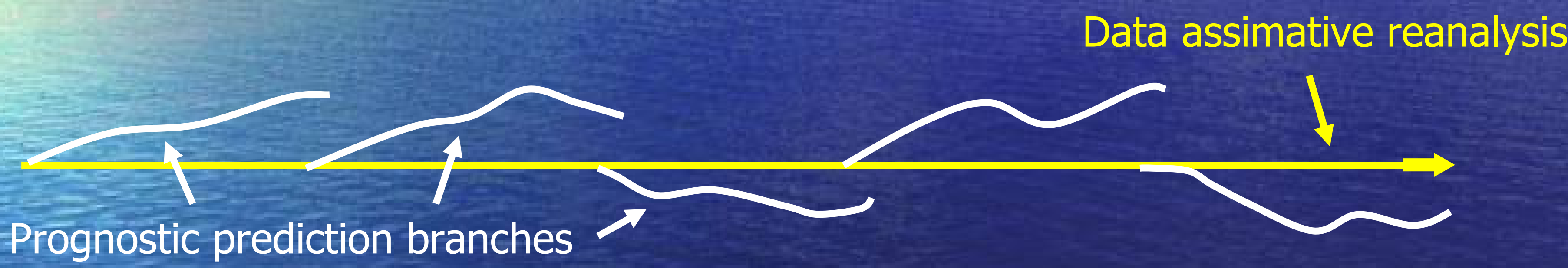


ORCA025 Work in Progress

- ✓ Reproducing Mercator’s 14-day operational forecast run initialized on April 18 2007;
- ✓ Bring Mercator forcing subroutines into BIO version;
- ✓ Assess difference between two versions;
- ✓ Assess differences between using 50 (operational) and 46 (GOAPP R&D) vertical levels;
- ✓ Introduce GEM forcing into NEMO;
- ✓ Preparing for NEMO-GEM coupling (target December 2007)

Reanalysis experiments

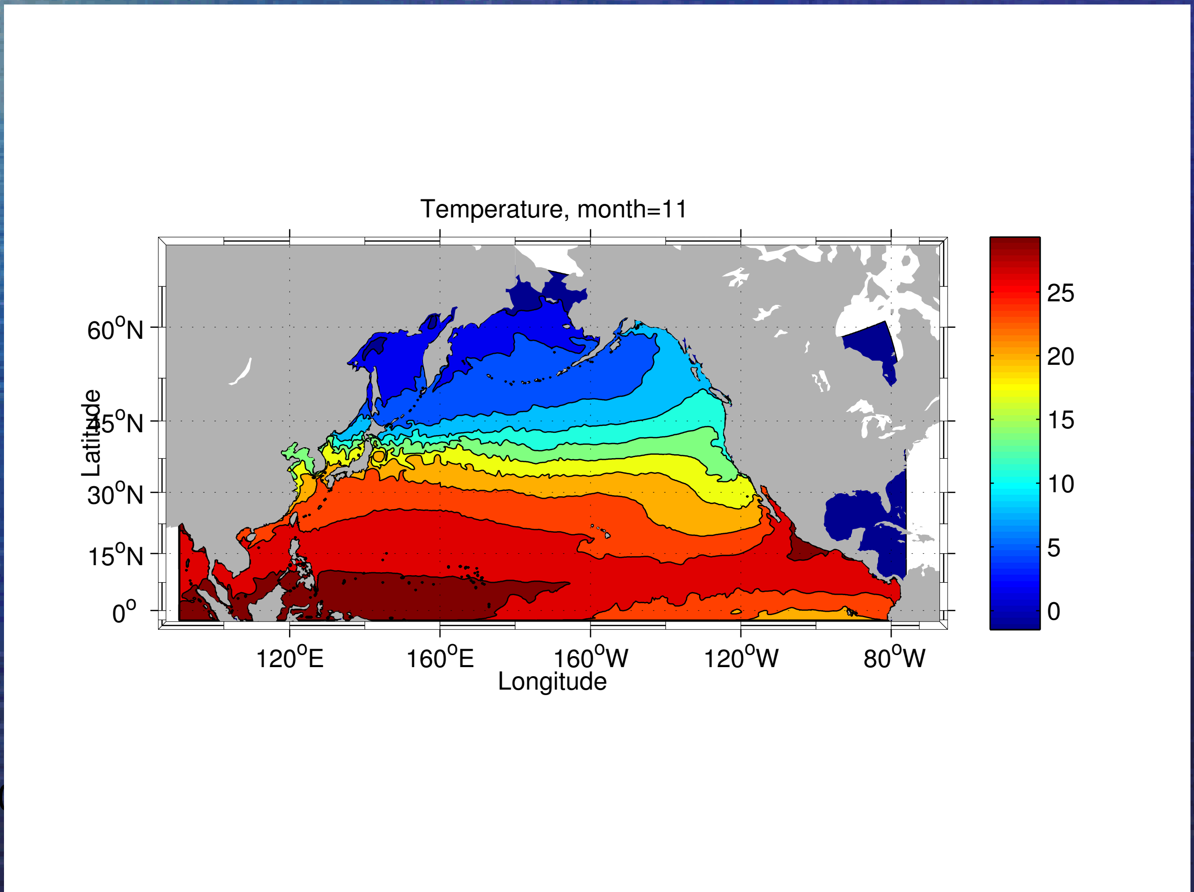
- As part of the CFCAS project, we will do ocean reanalyses for at least the satellite era which will be used for assessing predictive capability with different model formulations and data assimilation schemes.



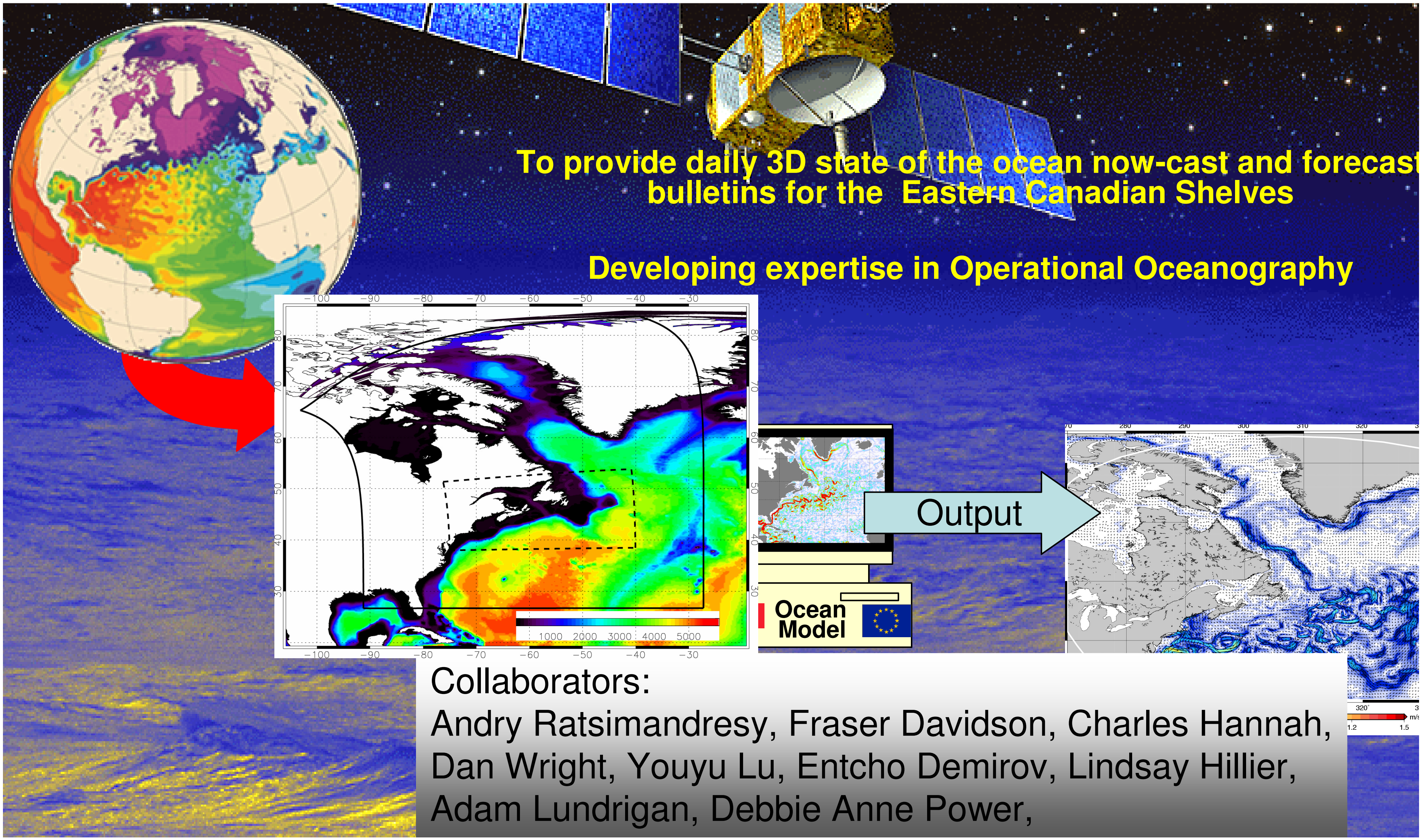
- Initial conditions for climate models and open boundary conditions for regional models will be provided to colleagues.

NEMO at Royal Military College (Stacey)

- ORCA1 and ORCA025 for North Pacific
- Spectral nudging implemented
- Simulations starting



C-NOOFS Update for MERCATOR – Canada MOU discussion

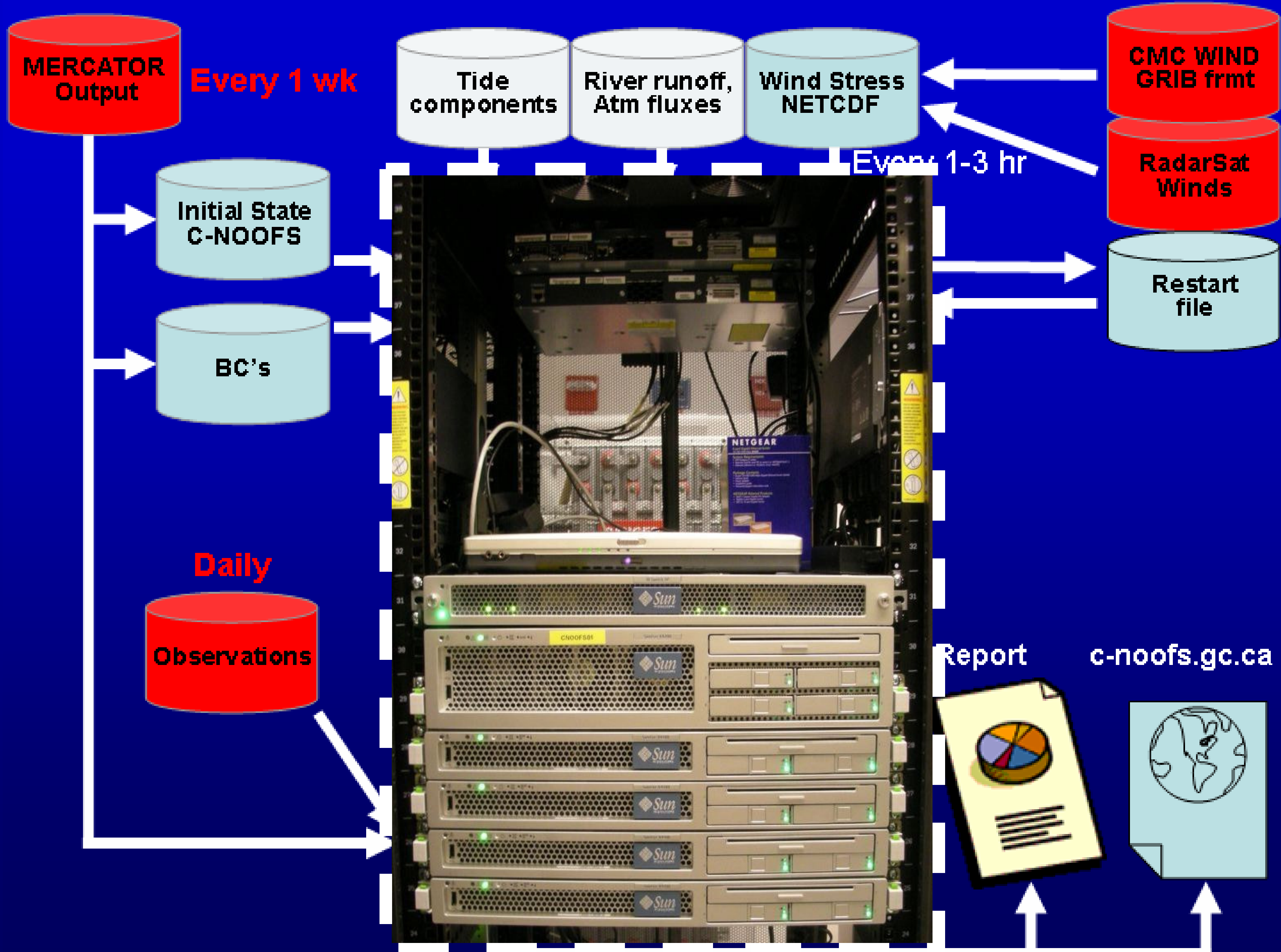


To provide daily 3D state of the ocean now-cast and forecast bulletins for the Eastern Canadian Shelves

Developing expertise in Operational Oceanography

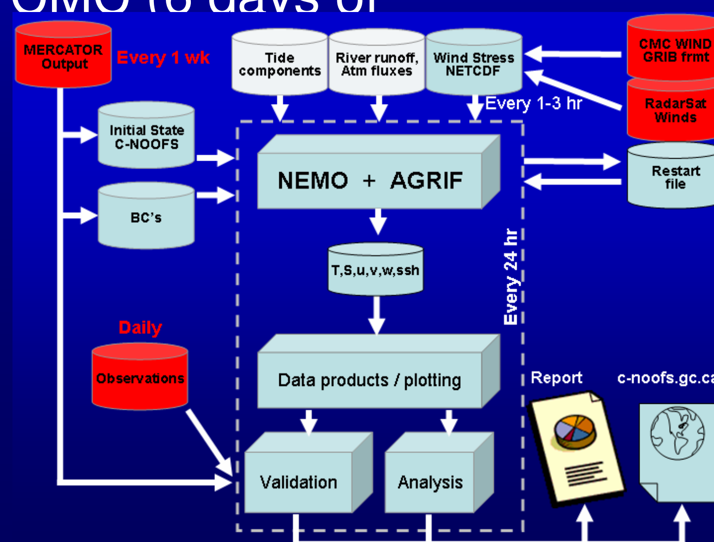
Collaborators:
Andry Ratsimandresy, Fraser Davidson, Charles Hannah, Dan Wright, Youyu Lu, Entcho Demirov, Lindsay Hillier, Adam Lundrigan, Debbie Anne Power,

C-NOOFS System



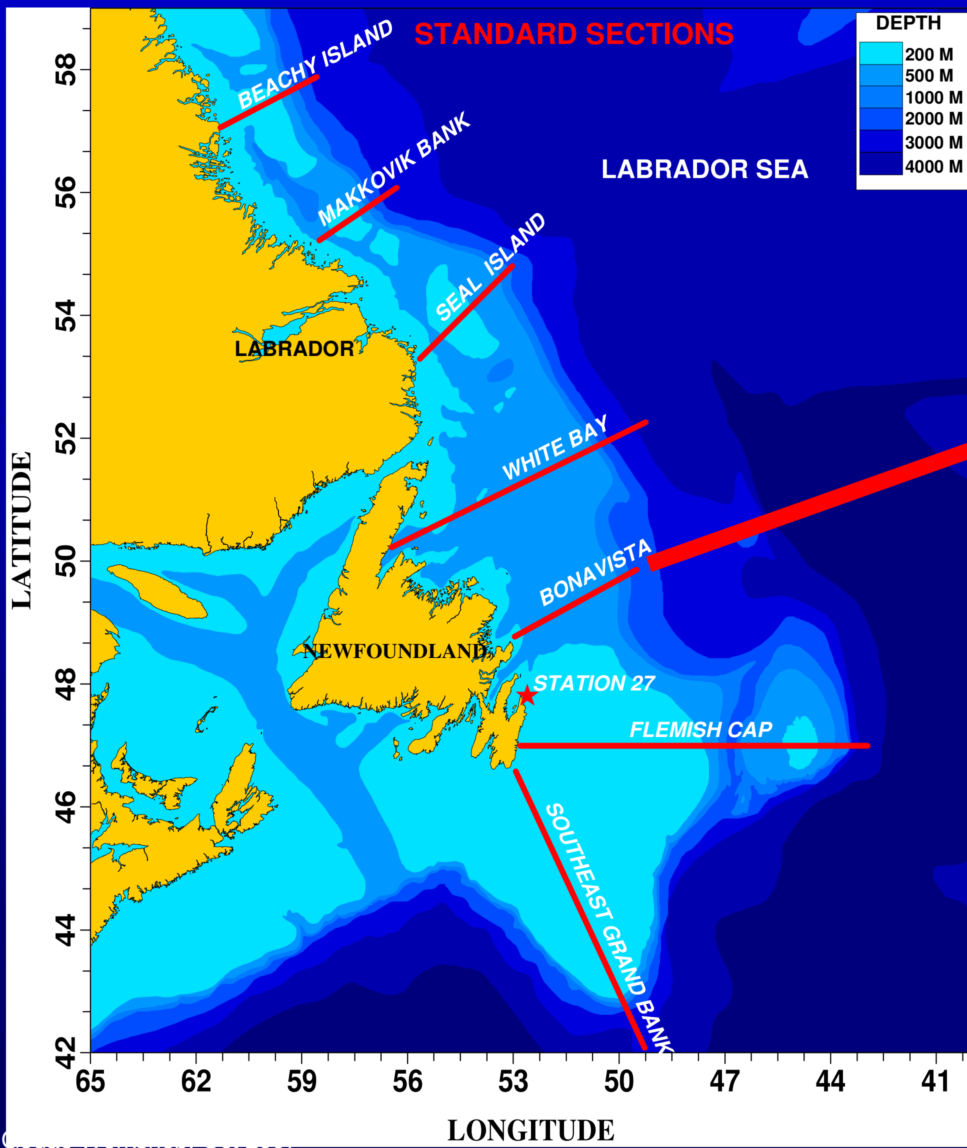
Present Configuration C-NOOFS

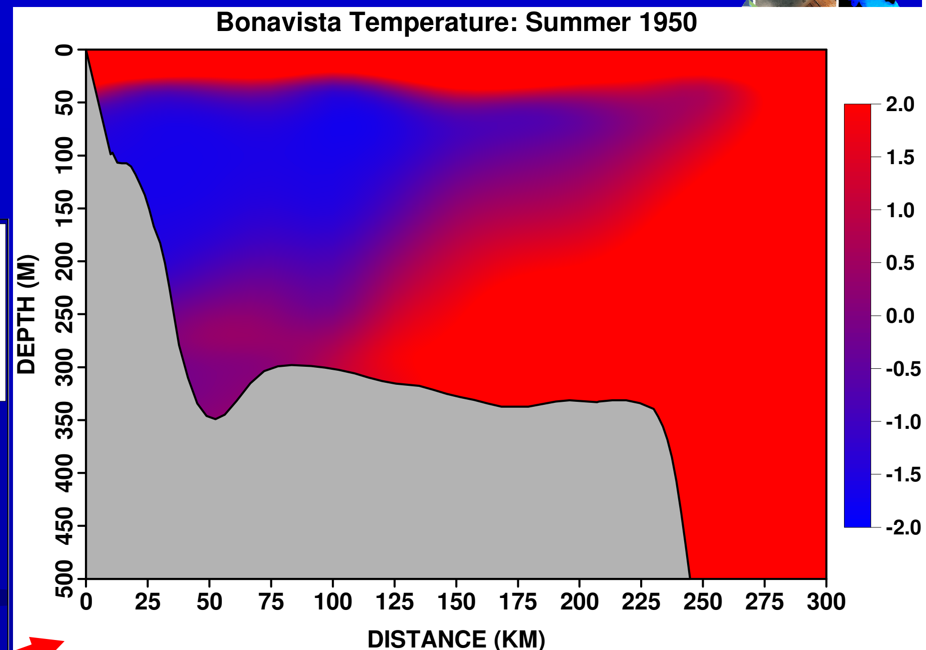
- ¼ resolution (sub-set of ORCA025), 46 levels (upgrading to PSY3v2 levels)
- Initialized with Mercator 3-D field every week (T, S, and ssh)
- Tides and free surface
- Nested within Mercator through open boundaries S – E (daily update of the OBC)
- Forced with 33-km surface wind field from CMC (6 days of forecast)
- Runs once daily (experimental)
    - www.c-noofs.gc.ca
- 7 days of hindcast+ 6 days of forecast

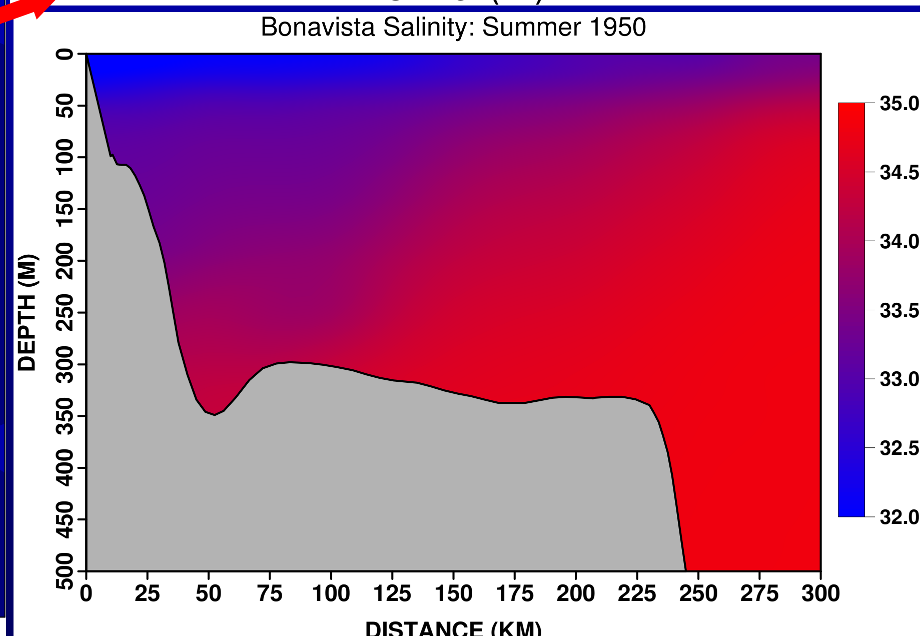


October 25, 2007

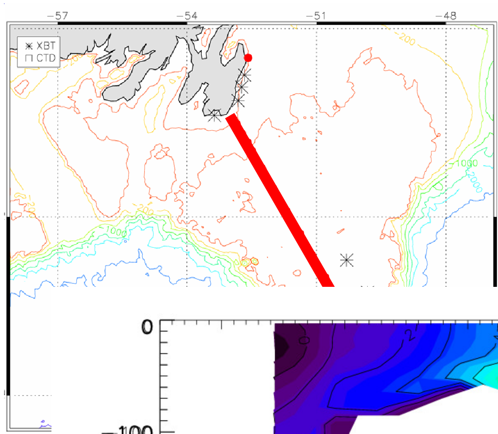
LONG TERM OCEAN CLIMATE MONITORING SECTIONS

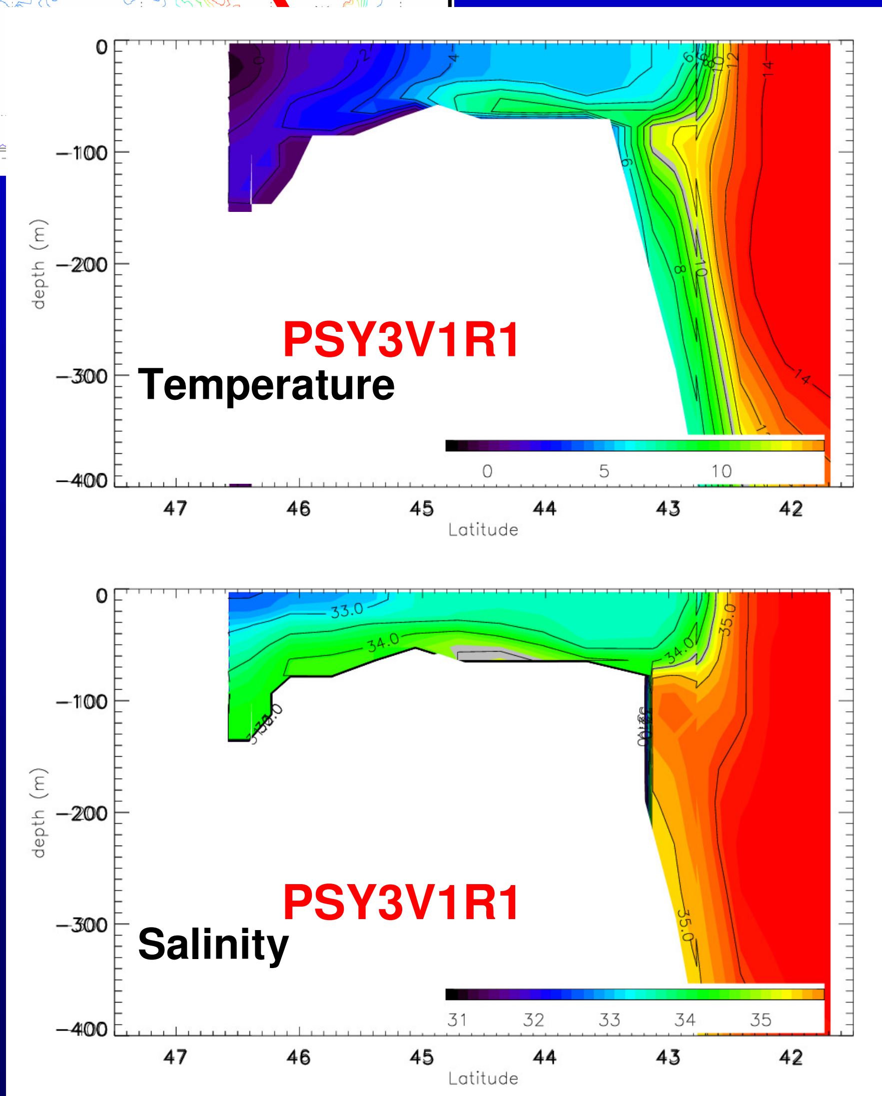


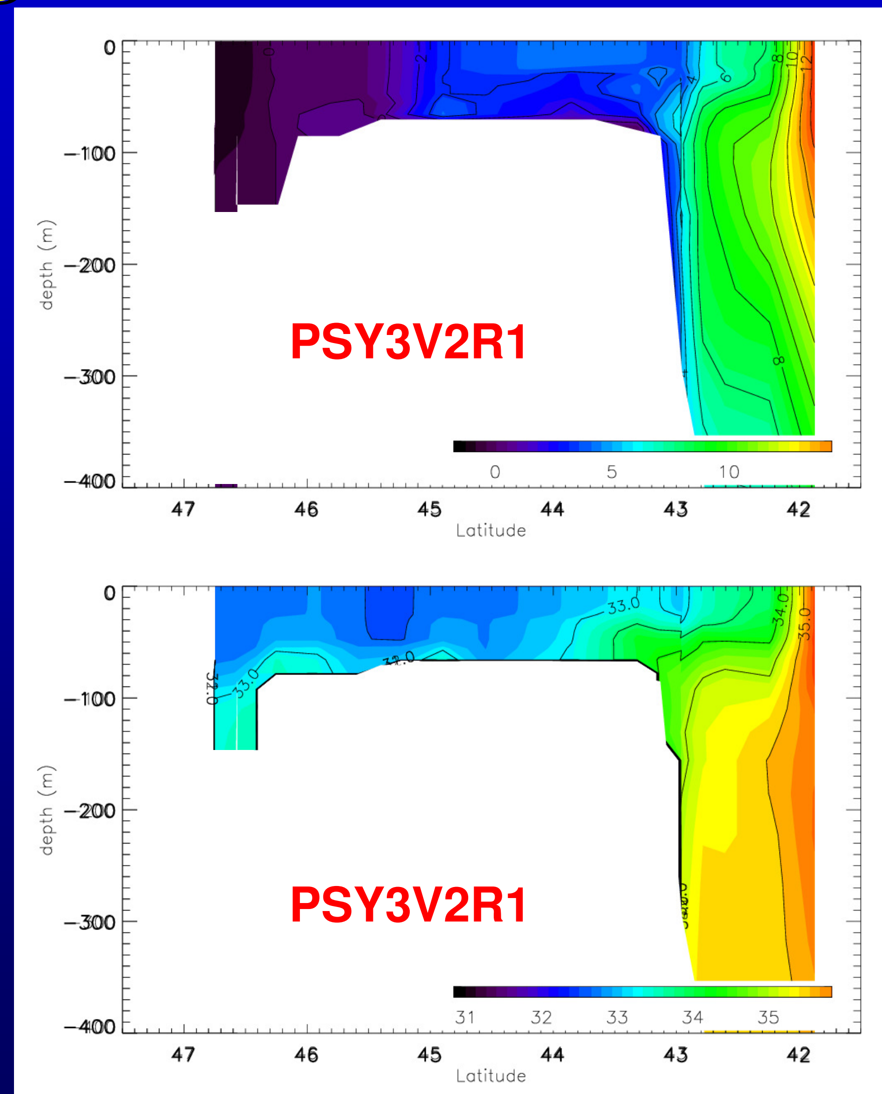




Comparison of Mercator PSY3 V1 and V2 along the AZMP transects

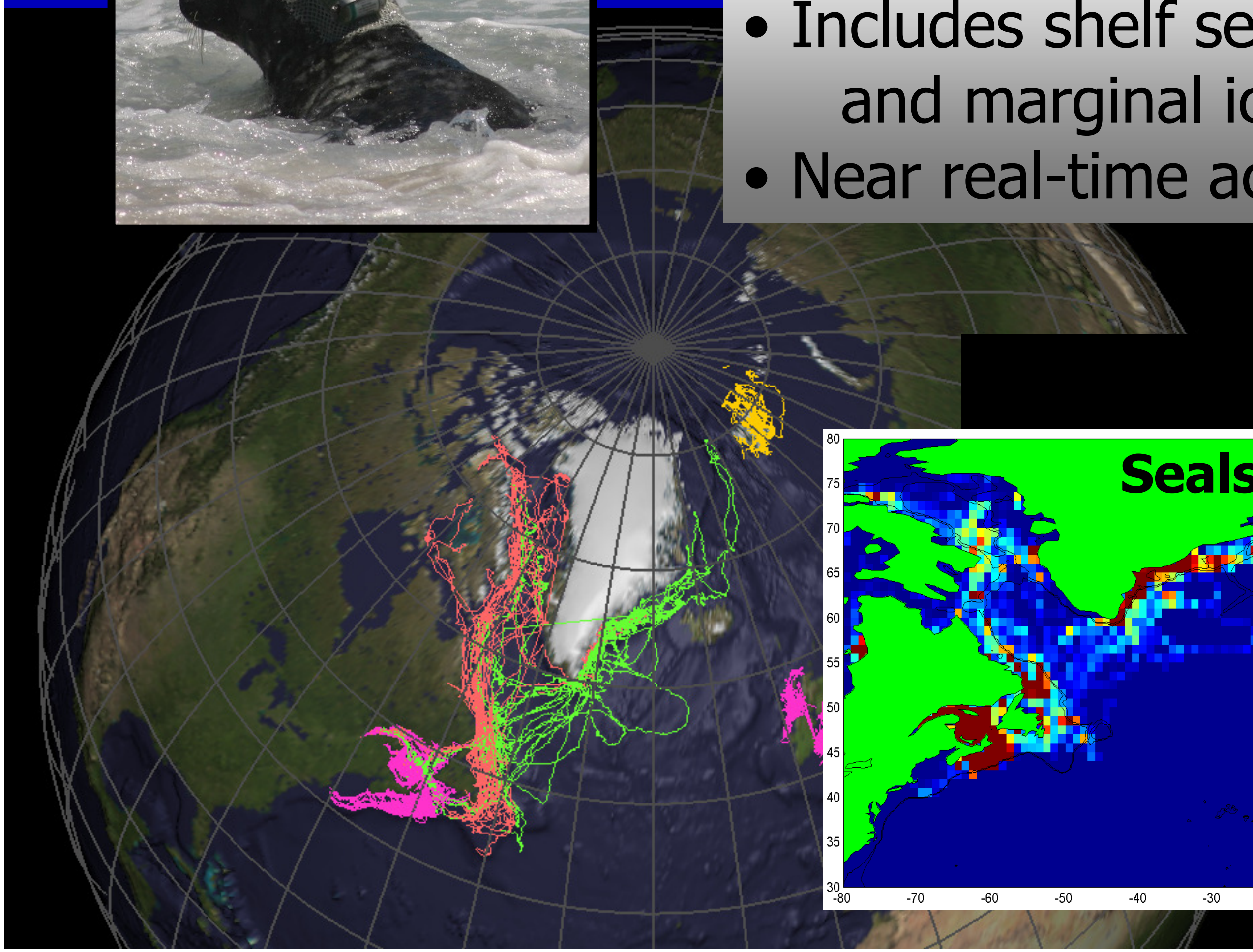


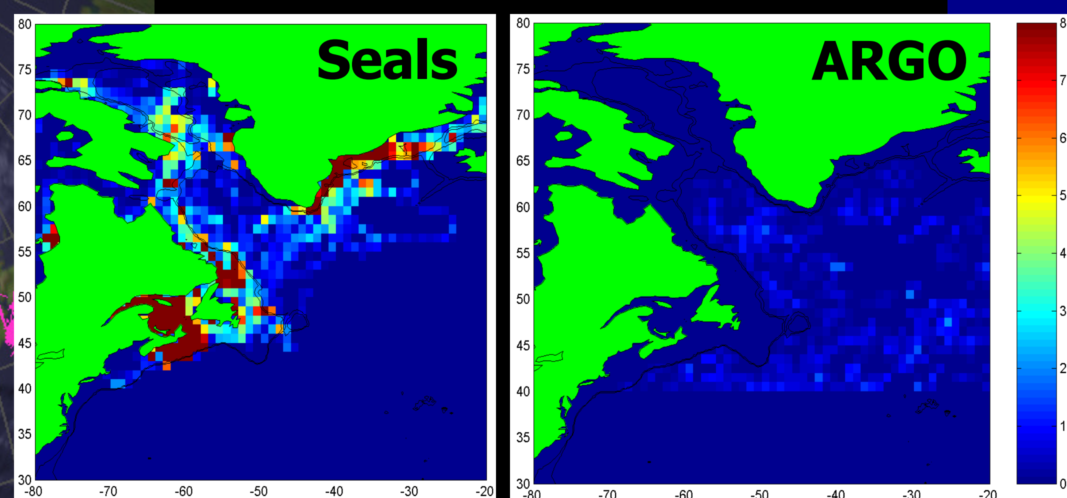




Supplementary regional observations

- Impressive coverage by seals
- Next generation to include both T & S
- Includes shelf seas
  and marginal ice zones
- Near real-time acquisition





Future works and improvements

- Tuning of the physical parameters
- Improvement of the initial conditions (PSY3V1R1 to PSY3V2R1)
- Implementation of the AGRIF for high resolution domain

- Run-offs, flux exchange (net downward flux, shortwave radiation, and net upward water flux)
- Ice model

- Computer upgrade for 1/12th of a degree North Atlantic
- 1/12th of a degree + 1/36th 2 way nested zoom is very expensive (10 times present capacity of 20 cores).

End users in Canada exist

- Canadian Coast Guard
- Canadian Ice Service
- Oil industry
  - Pack ice
  - Ocean Currents
  - Observations
- Fisheries and Oceans
  - Aquaculture: Use of FVCOM for downscaling to near shore
- Oil service industry:
  - Produced water drift
- Environment Canada
  - Ice service + weather service




www.ec.gc.ca

Overview of the Sea-Ice Data Assimilation Project

Meteorological Research Division and
Canadian Ice Service
Environment Canada

Mark Buehner, Tom Carrieres
and Alain Caya
10 October 2007

Background

- [redacted]: to develop an automated ice analysis system for:
  - [redacted] Ice Service (CIS): ice concentration, thickness/type distribution, [redacted] strength and edge, deformed ice at ~1-2 km resolution
  - [redacted] concentration, thickness, albedo, surface emissivity at ~5 km
- [redacted]n between CIS and Meteorological Research
- [redacted] experience with variational and ensemble-based [redacted] for NWP:
  - [redacted]ional approach: incremental 3D-FGAT (first guess at appropriate
- [redacted]nitial prototype analysis system using CIS ice-ocean model [redacted]n east-coast → plan to port system to other models/regions:
  - [redacted] Arctic archipelago region (IPY project, Polar-GEM)
  - [redacted]. Lawrence (coupled ice-ocean-atmosphere model developed at [redacted]

Observations that can be assimilated

- Total ice concentration from:
  - CIS Daily ice charts (manual fusion/nowcast of multiple data sources)
  - CIS RadarSAT image analyses (manual human analysis/retrieval)
  - Nasa-Team-2 (NT2) ice concentration retrievals from SSM/I or AMSR-E data
- Passive microwave brightness temperatures (in progress):
  - Using a simple radiative transfer model
  - Passive microwave data from AMSR-E and SSM/I
  - Provides information on ice concentration and other ocean/atmosphere variables (e.g. SST, surface wind speed)
- ARGO Temperature-Salinity profiles
- Sea Surface Temperature

Background-error statistics

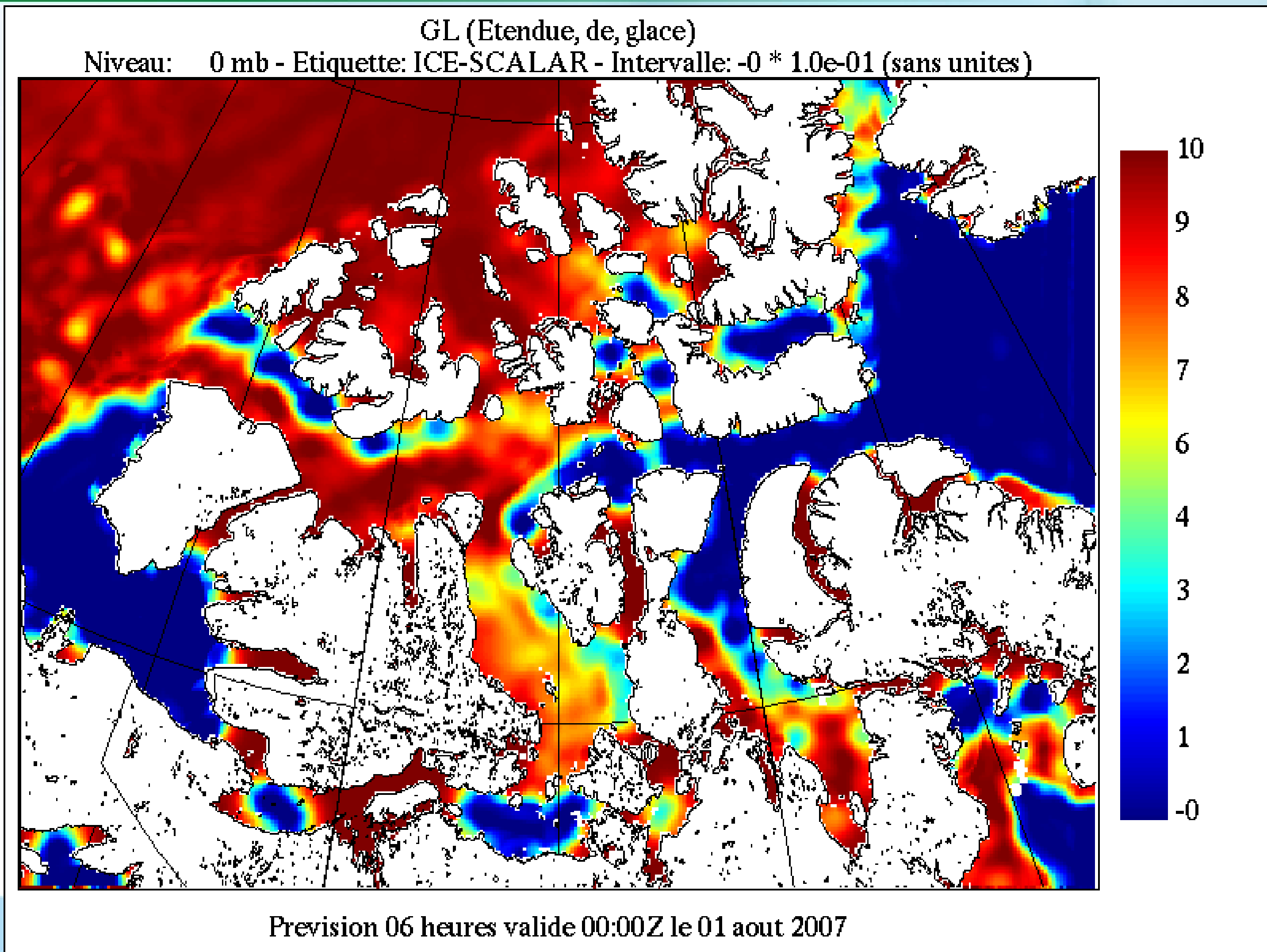
- Important for e.g. spreading information from ice observations to ocean variables for coupled ice-ocean model
- Estimated using an EnKF with stochastic atmospheric forcing from the CMC global Ensemble Prediction System, assumed stationary in time
- Vertical covariance matrix for (Ice concentration, T, S) on depth levels, including multi-variate relationships
- Horizontal correlations:
  - Modelled using a diffusion operator
  - Correlations have Gaussian-like shape, but length scale can vary with location
  - “Feels” complex lateral boundary conditions in coastal areas, important for Canadian Arctic region

Canadian Arctic Archipelago

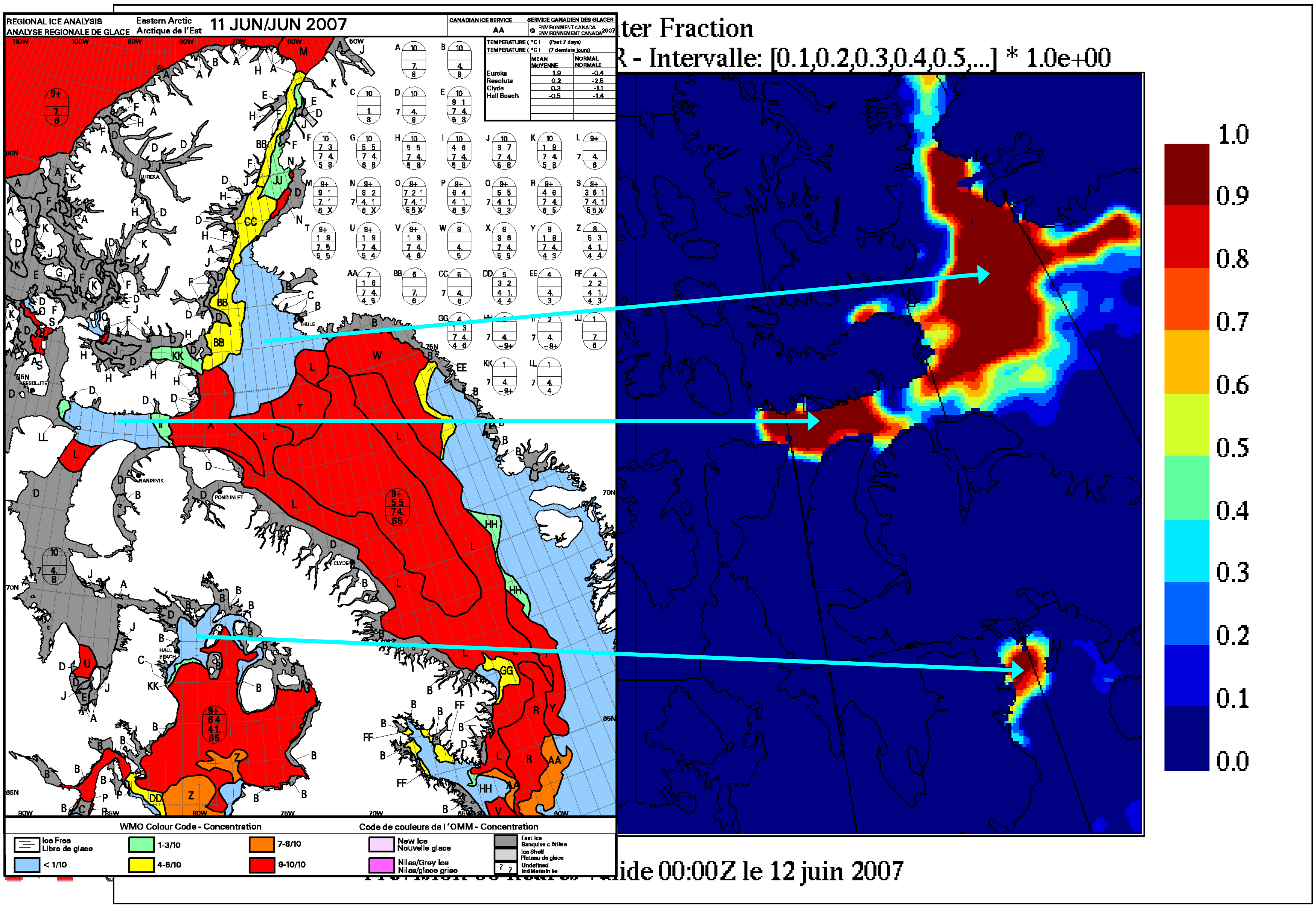
- First experiment in Archipelago region:
  - 5-km horizontal resolution on rotated lat-lon grid
  - 12-h assimilation windows, twice a day
  - Assimilation of AMSR-E NT2 total ice concentration
  - Persistence is assumed between assimilation windows (ice-ocean model not yet available)
  - Background-error horizontal correlations are modeled using the diffusion operator with a 30-km correlation length scale
- Future plans:
  - Assimilate additional data: RadarSAT image analyses, OSI-SAF ice concentration product, possibly AVHRR ice concentration
  - Use ice-ocean model to produce background state

Canadian Arctic Archipelago

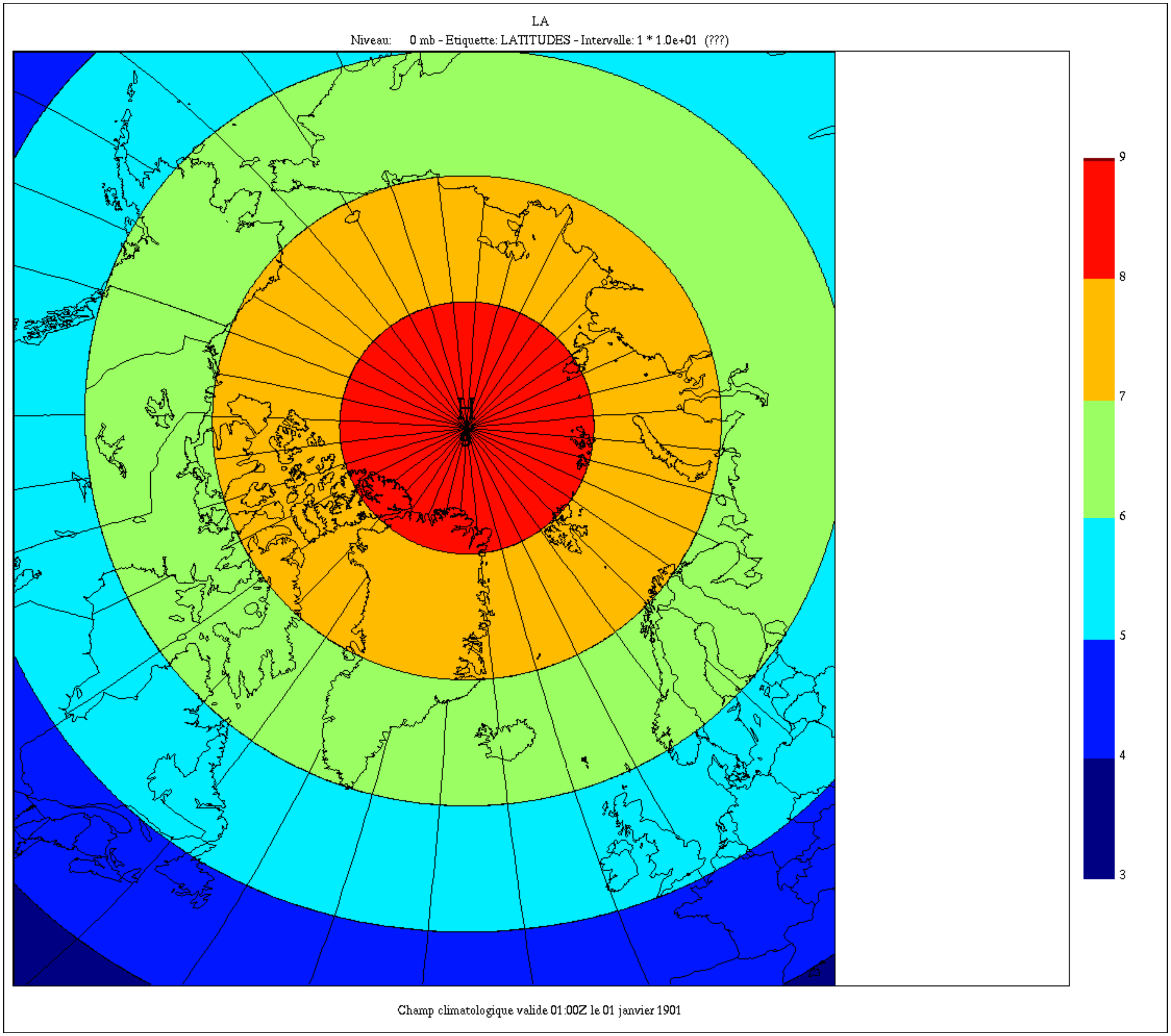
(example of ice concentration analysis in tenths for 1 August, 2007)



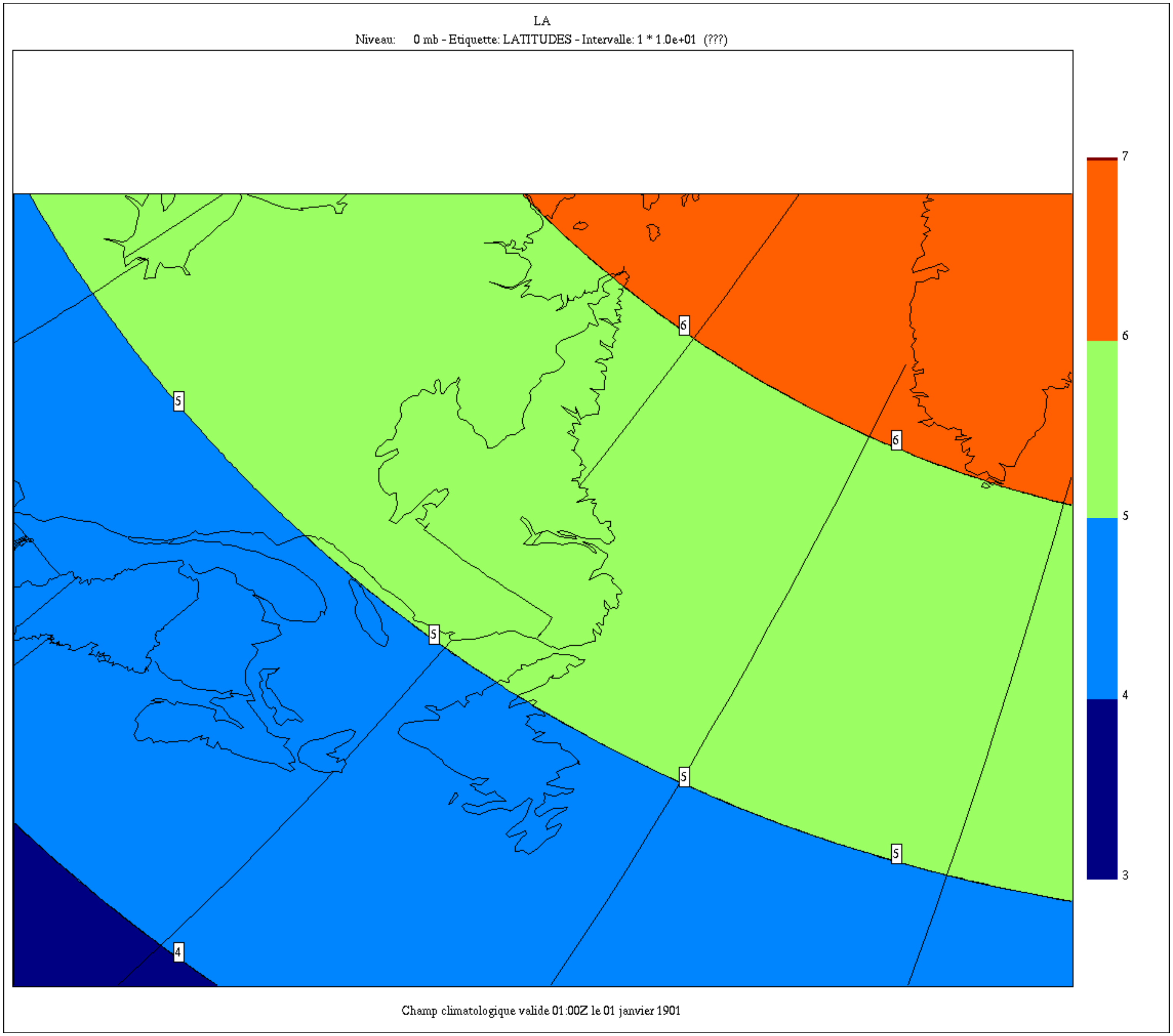
Open Water Fraction analysis



Polar-GEM research version grid (479x539) (resolution=15km)



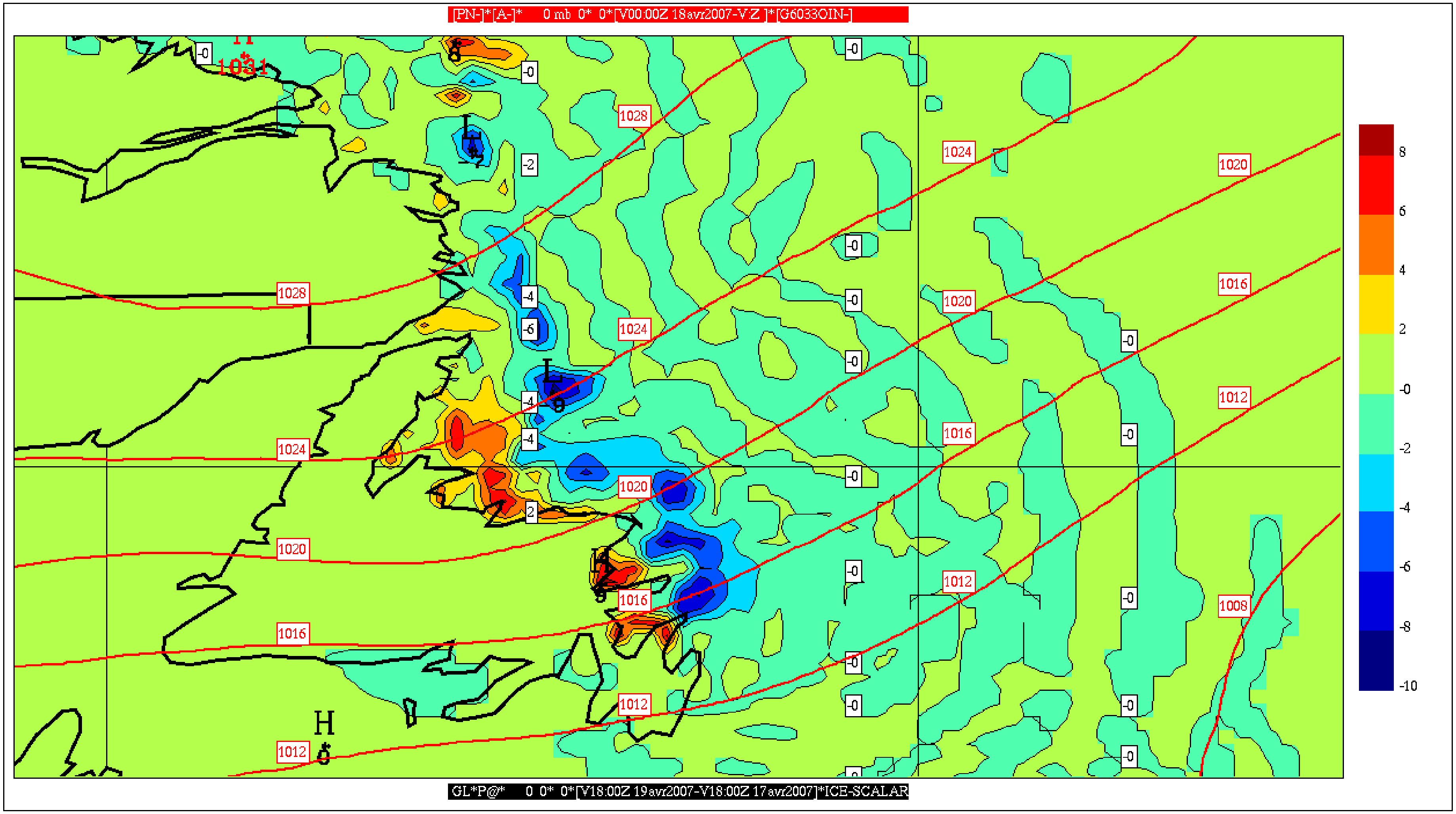
Sub-grid of Polar-GEM grid (200x150) (resolution=15km)



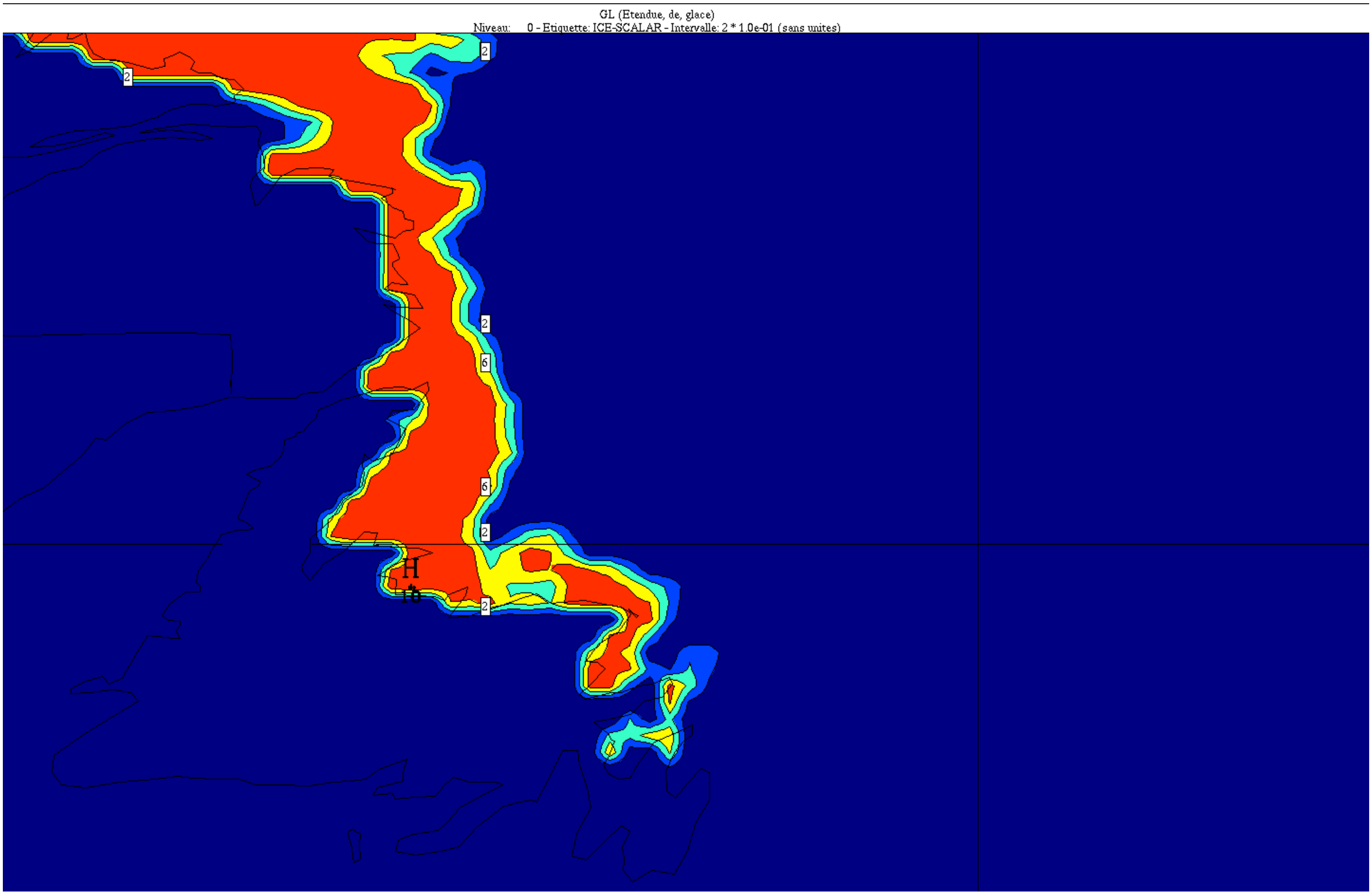
Proposed grid to study the case of the third week of April 2007 when severe ice conditions trapped many vessels on the North-East coast of Newfoundland

GL(19av18z) – GL(17av18z) :
48 hours ice field difference showing important advection of ice on the North-East coast of Newfoundland

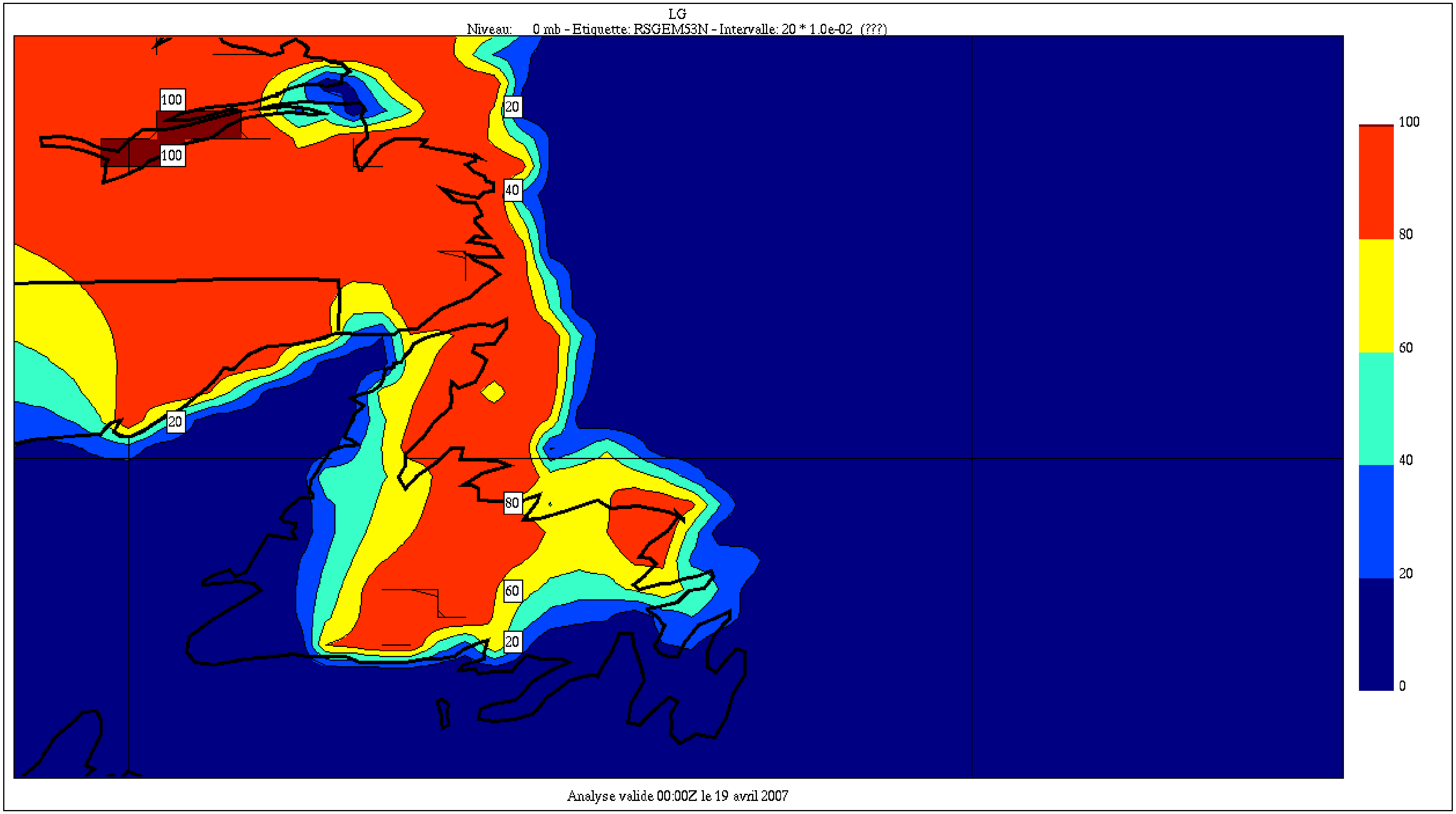
PN (18av00z) (red lines) : MSL pressure showing strong northeasterly winds



Caya and Buehner 19av06z ice analysis (resolution=5km)

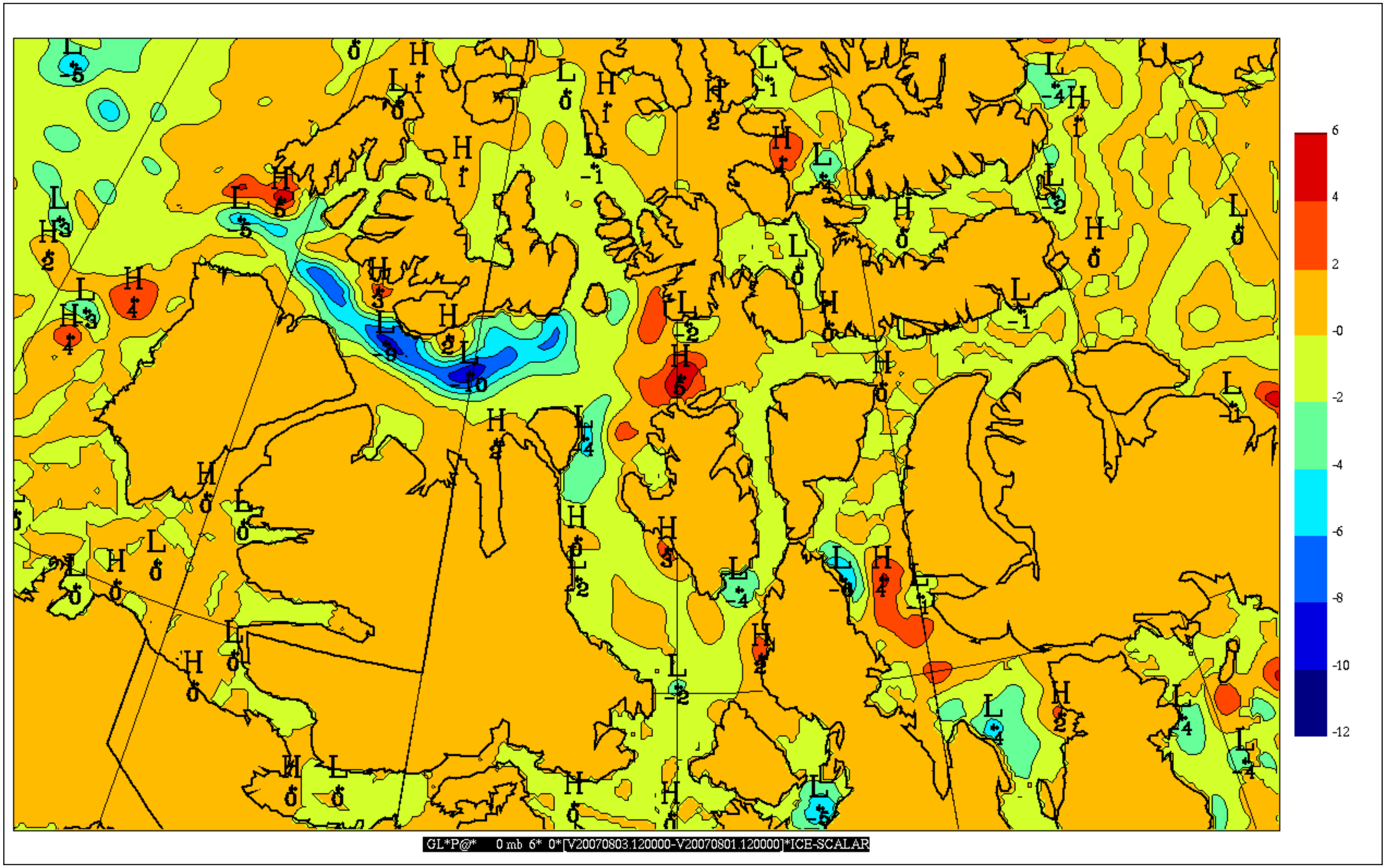


CMC 19 av00z ice analysis (resolution=35km)

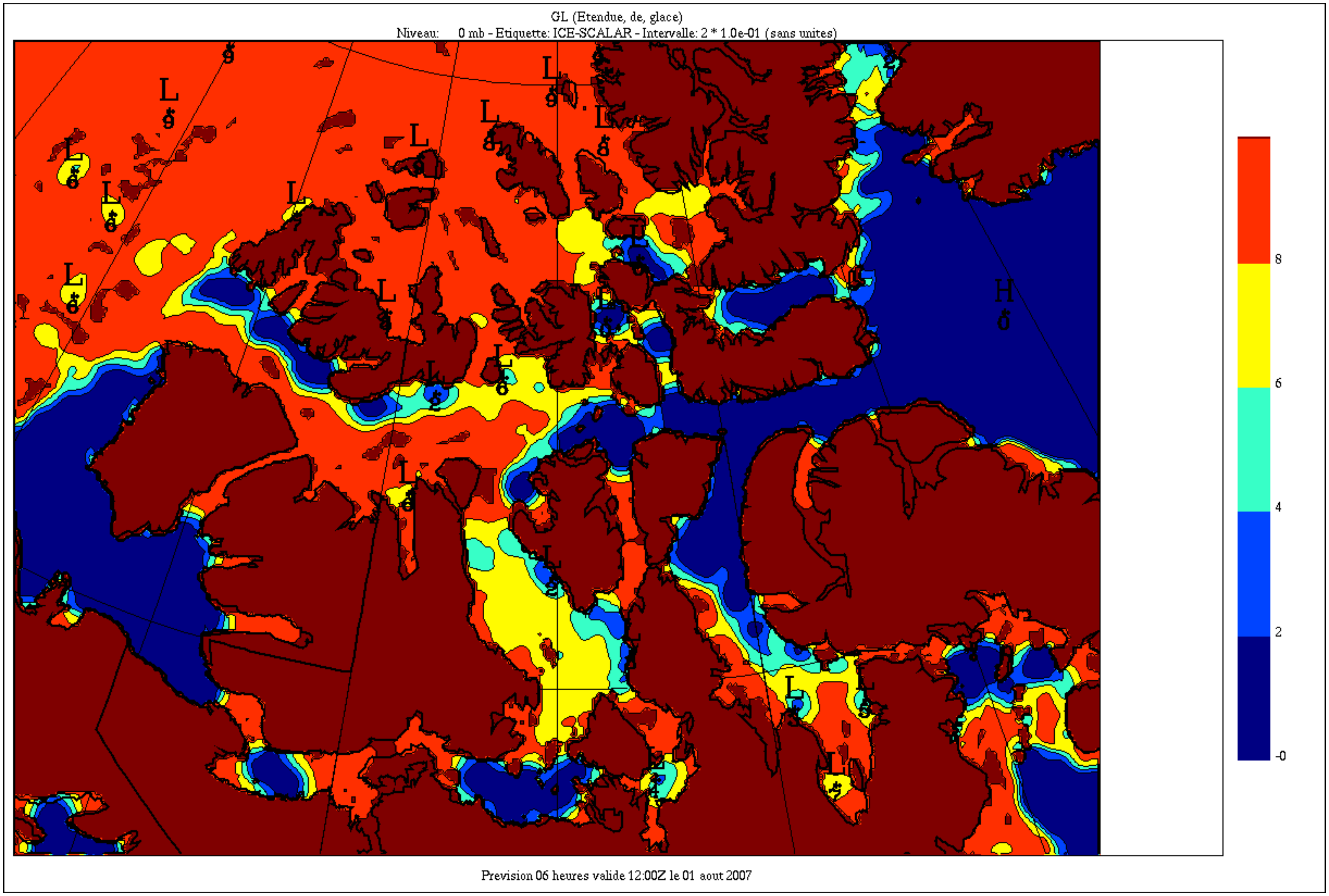


GL(03au06z) - GL(01au06z)

48 hours ice field difference showing rapid melting over NW passage



Caya and Buehner 01au06z ice analysis (resolution=5km)



Short Term Predictability of the North Atlantic

Yimin Liu[1], Keith Thompson[1] and Youyu Lu[2]

1: Dalhousie University

2: Bedford Institute of Oceanography

Goals

This Study: Assess impact of ocean initial conditions on the short term (1 to 60d) predictability of the North Atlantic.

Key points

- **New hybrid method for assimilating altimeter and Argo data shows promise**
- **Computationally efficient, multivariate, simplifies matrix specification**
- **Allows for complex TS relationships**
- **Regions of high and low predictability in the North Atlantic**
- **Identified and physically explained.**

The North Atlantic Model

•Based on POP code. 7°N-67°N and Hudson Bay excluded.

•1°/3 in longitude, equal spacing in x and y, 23 vertical levels.

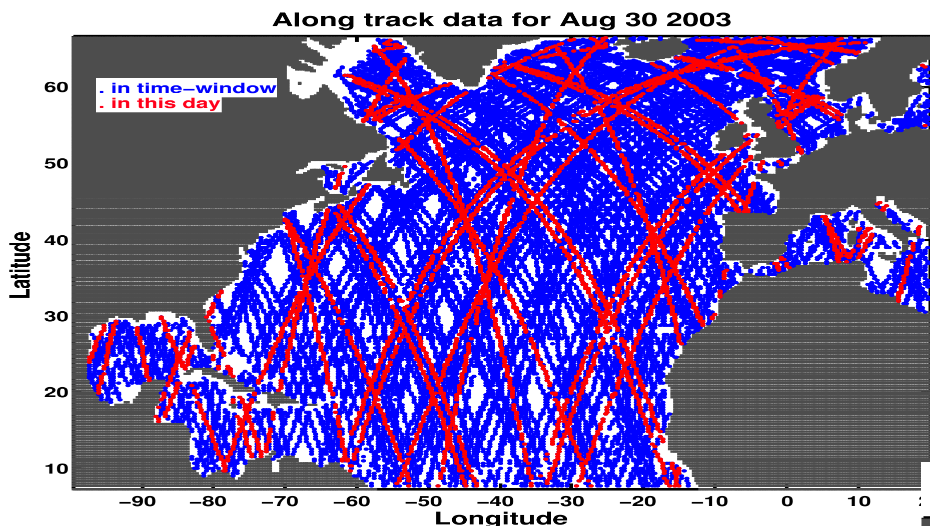
•Mixing parameterizations: KPP in vertical; biharmonic for momentum; along-isopycnal harmonic for tracers.

• Forcing: daily wind stress, heat flux and E-P from NCEP.

• Integration starts January 1, 1990.

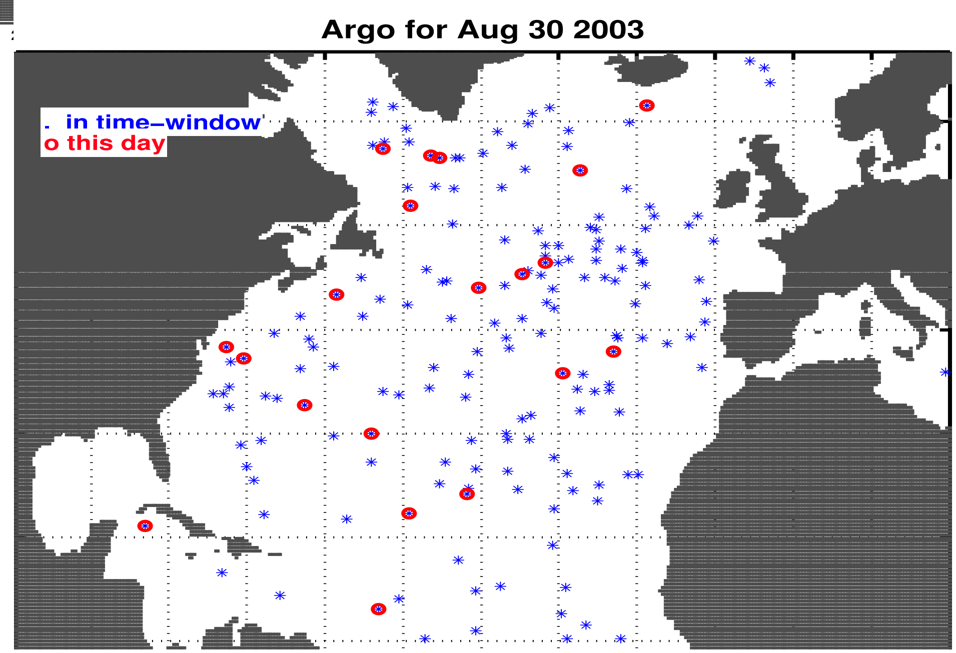
• T and S spectrally nudging to 1°/3 climatology of Yashayaev.

Data for Validation and Assimilation

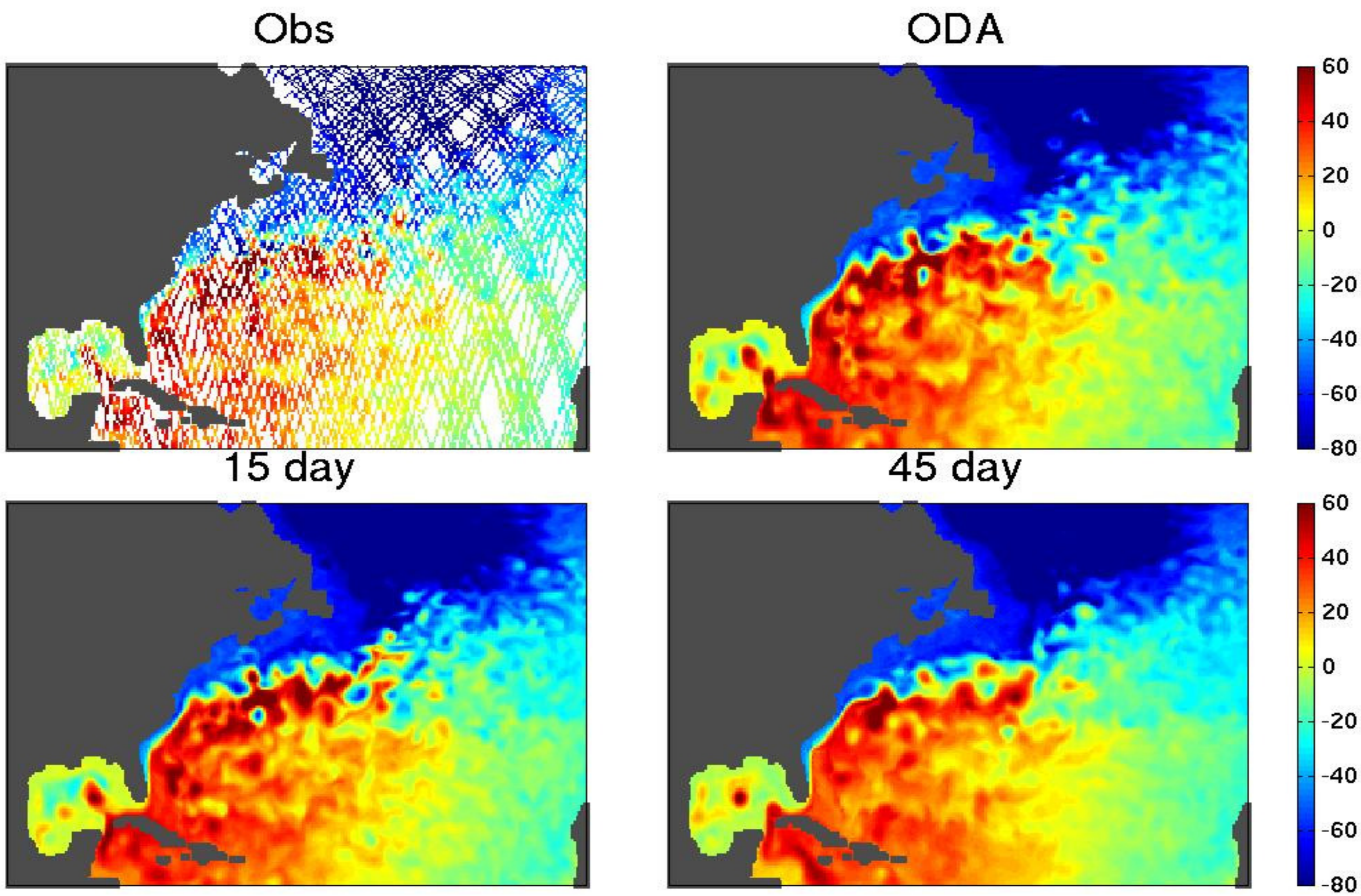


Altimeter data: 1992-2006; along track data; mapped to analysis time using 7d sliding window.

Argo TS data: 1997-2006; QC; Lagrangian interpolation to analysis time and grid.

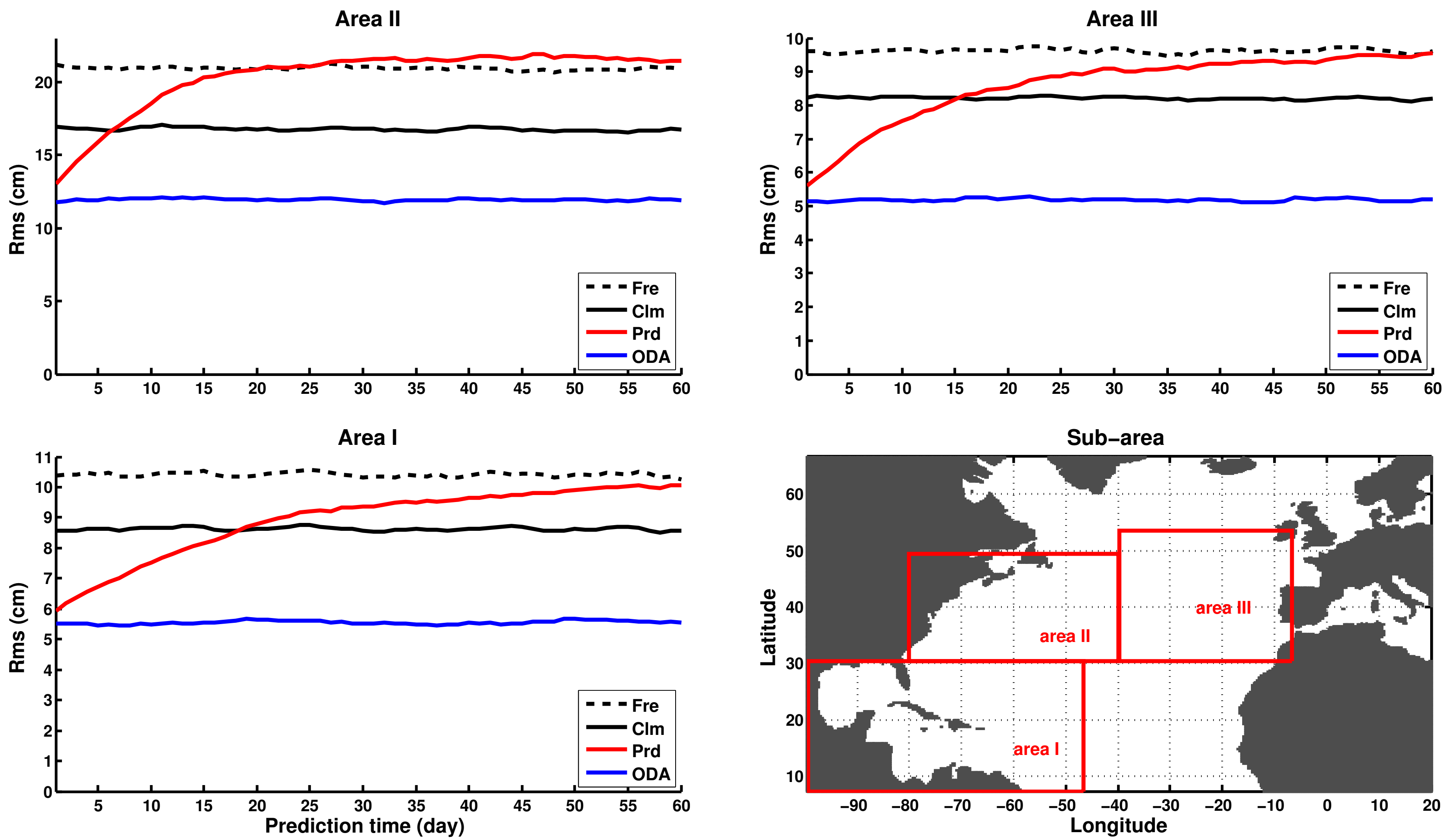


Prediction for August 7 of 2004



Predictability as a Function of Lead Time

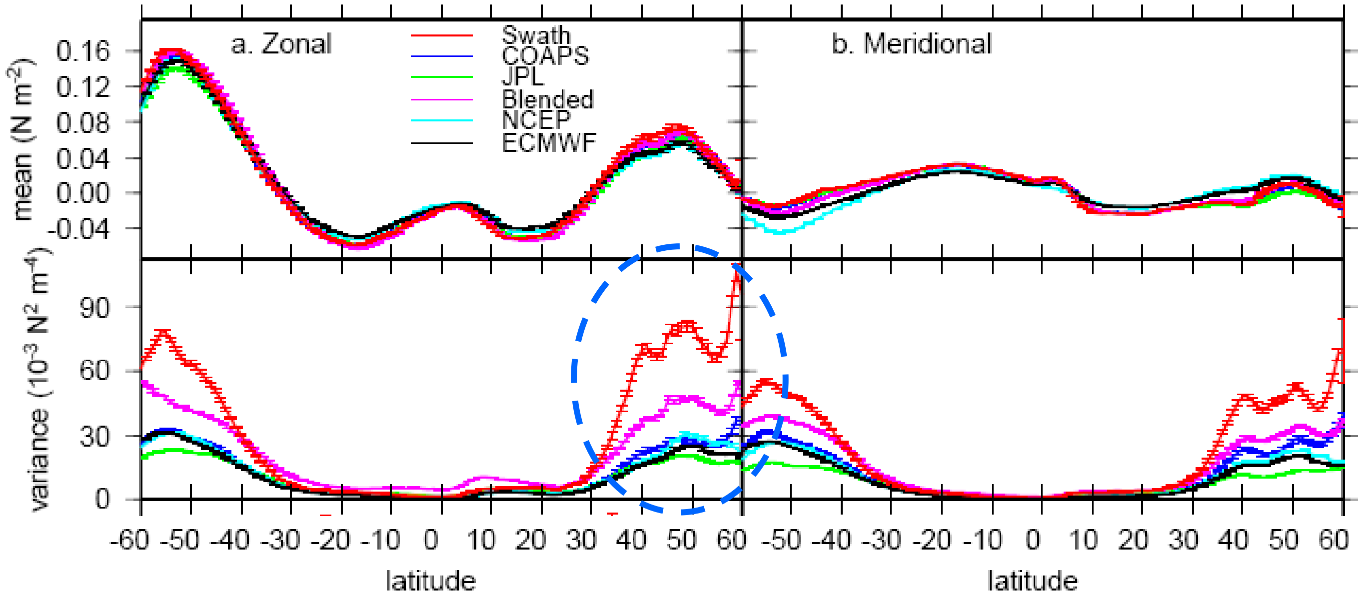
RMS(Observed sea level - Prediction)



Sensitivity of a forecast error covariance of coarse resolution ocean model to a wind stress error covariance

Tsuyoshi Wakamatsu, Mike Foreman, Patrick Cummins, Josef Cherniawsky (IOS/DFO)

Motivation: high discrepancies among standard wind stress data sets (Gille, 2005)



Reanalysis wind stress data sets have lower levels of variance compared to satellite measurements

Question: When we take into account the discrepancies as wind stress error in 4DVAR (e.g. Stammer et al. 2002,2003), we still need to assume a covariance function. How sensitive is the analysis to the assumption?

Study Objective:

To examine sensitivity of the forecast error covariance of an ocean GCM to spatial and temporal decorrelation scales in the wind stress error covariance.

Système de prévision numérique Atmosphère-Océan-Glaces pour le Golfe du St-Laurent. Impact du couplage pleinement intéractif. (Modélisation Environnementale)

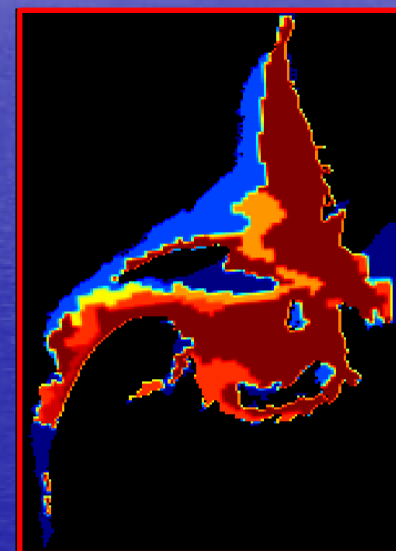
P. Pellerin, H. Ritchie
F. Roy, F. Saucier
and
S. Desjardins, V. Lee, M. Valin

Recherche en Prévision Numérique
and
Institut Maurice Lamontagne (MPO)

Coupler

tion, Thickness and
ature
Temperature .

Ocean



00 seconds

Coupler

Vis flux, Humidity,
re, Winds
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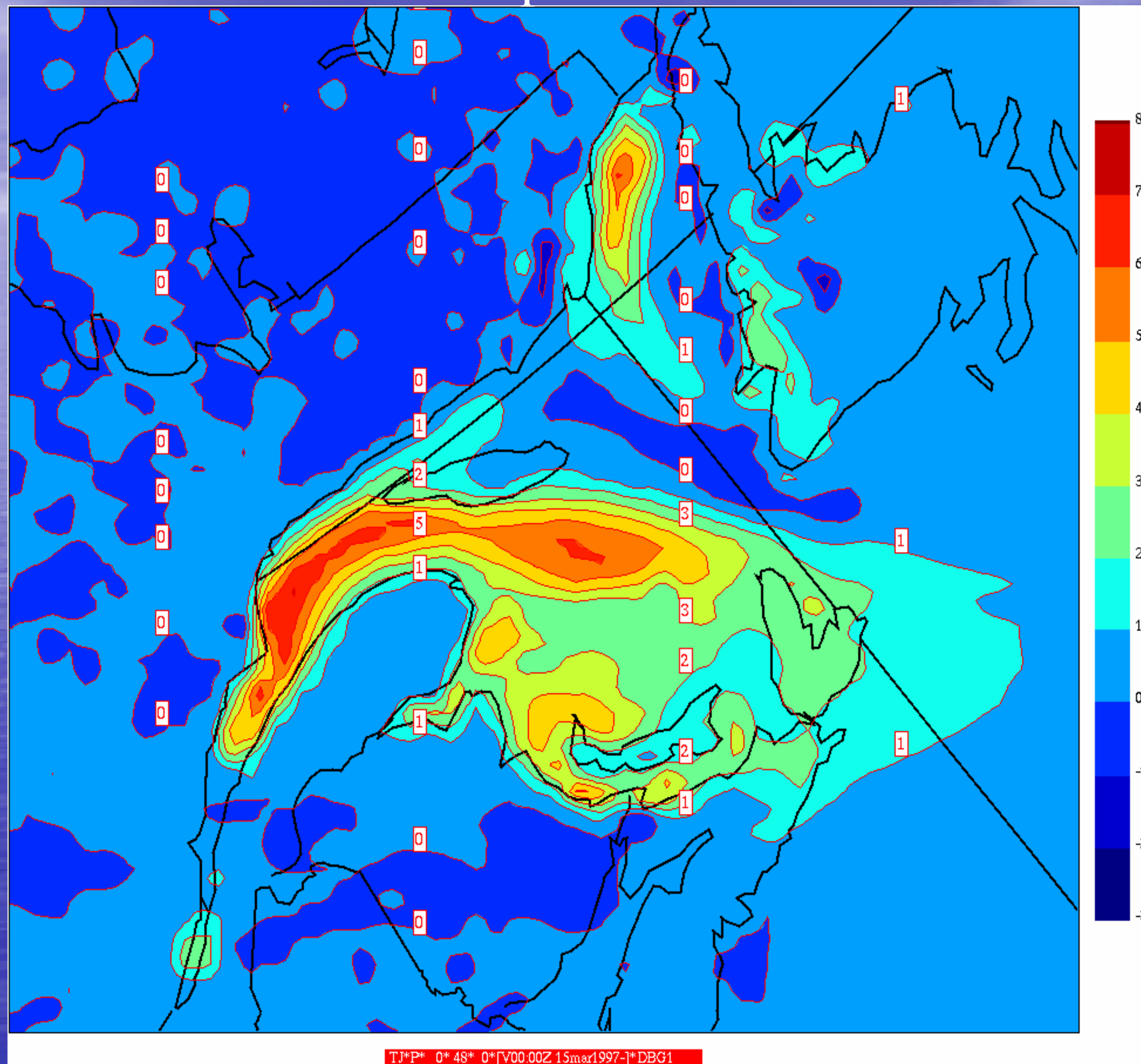
5 km
timestep=300s

2 way Coupling - 1 way Coupling
Surface temperature V 00Z 15



Implementation of an Atmosphere-Ocean-Sea Ice Coupled Model in the Canadian Meteorological Centre (CMC) Operational Forecast System

Faucher, M; Pellerin, P; Roy, F; Valcke, S; Desjardins, S; Desgagné, M; Saucier, F; Lefaivre, D; Ritchie, H; Carrières, T

Ενϖιροννεμεντ Χαναδα　Ενϖιρονμεντ Χαναδα

Π| χηεσ & Οχεανσ Χαναδα　Φισηεριεσ & Οχεανσ Χαναδα

Next steps

- Finish milestones and deliverables to complete implementation plan
- Sign EC-DFO-DND MOU for Canadian collaboration
- Presentation of plan to and by senior EC, DFO, DND managers to seek required long-term resources
- Finalize partnership with Mercator and move the initiative into the pre-operational stage

Objectives for this meeting

- Ensure mutual understanding of intentions
- Finalize Letter of Intent on Mercator-Canada Partnership
- Plan interactions and communications on scientific & technical issues – points of contact within Mercator & Canada, how channels of communication & coordination will work
- Plan installation of Mercator data assimilation system in Canada

(Draft) outcomes of meeting

- Mercator team (Director General Pierre Bahurel, Science Director Eric Dombrowsky, legal advisor Anthony Talandier) impressed by Canadian resources and progress
- Canada is foreseen as one of the partners in the new “My Ocean” activity under which Mercator will become the European Operational Oceanography Center over the next three years
- Mercator-Canada agreement will include scientific, technological, data and service collaborations and exchanges

Collaborations and exchanges

- Scientific: based on activities above
- Technological: mutually beneficial exchange of codes for computing infrastructure, diagnostics, verification, data assimilation and modelling
- Data: full exchange of relevant data (e.g., observations, analyses, model outputs)
- Service: links between Canadian and Mercator operational services and validations

Installing Mercator ODA system

- Included in technological collaborations and exchanges
- Discussed with Mercator scientists (Charles-Emmanuel Testut, Benoît Tranchant) during meeting
- Prefer Mercator scientist to visit Montreal and work intensively with a small technical team on installation and use of system
- Canadian team members would do other installations and training within CONCEPTS and GOAPP
- Arrangements are being pursued – Eric Dombrowsky is first point of contact within Mercator for scientific and technical issues

Plans for Coupled Atmosphere-Ocean Data Assimilation in GOAPP

Hal Ritchie [1,3] and Pierre Gauthier [2]
[1] Department of Oceanography, Dalhousie University
[2] Department of Earth and Atmospheric Sciences, Université de Québec à Montréal
[3] Meteorological Research Division, Environment Canada

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Outline

- Introduction
- MSC's data assimilation (DA) infrastructure
- Development of a coupled atmosphere-ocean data assimilation system
- First objectives
- I.2.1 Independent assimilation into coupled models
- I.2.2 Exploratory studies on joint assimilation into coupled models

Introduction to MSC Data assimilation

Numerical models play a key role in the production of MSC forecasts.

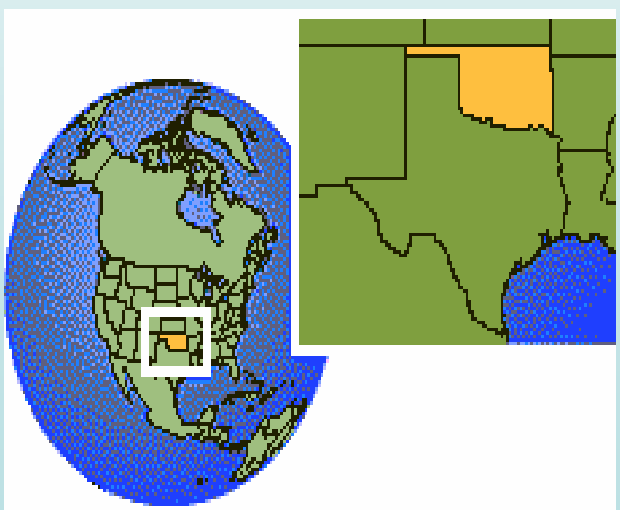
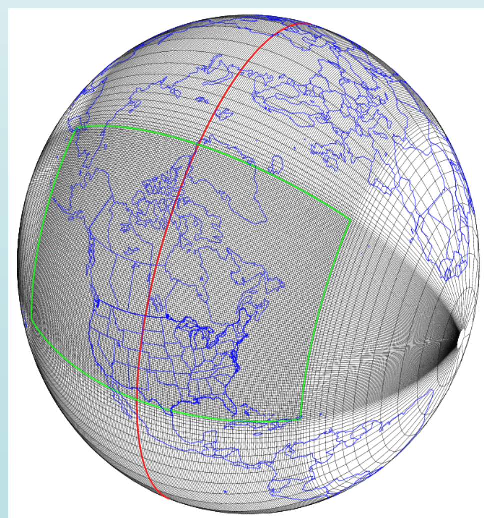
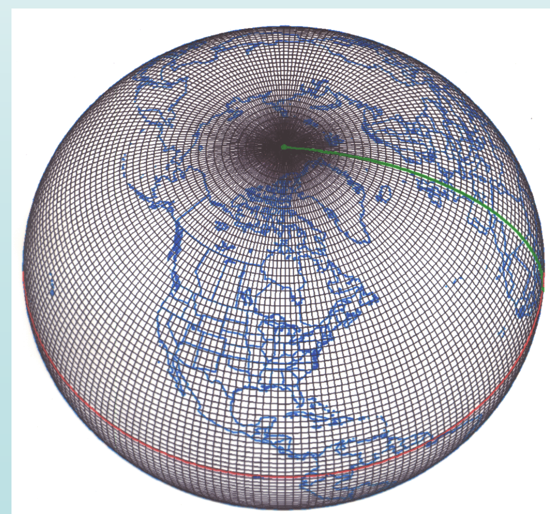
Accuracy depends on quality of numerical models, data, and the assimilation system that produces initial analyses from which forecasts run.

To start, models need initial values of variables (e.g., pressure, temperature, velocity, humidity) on the model 3D global grid.

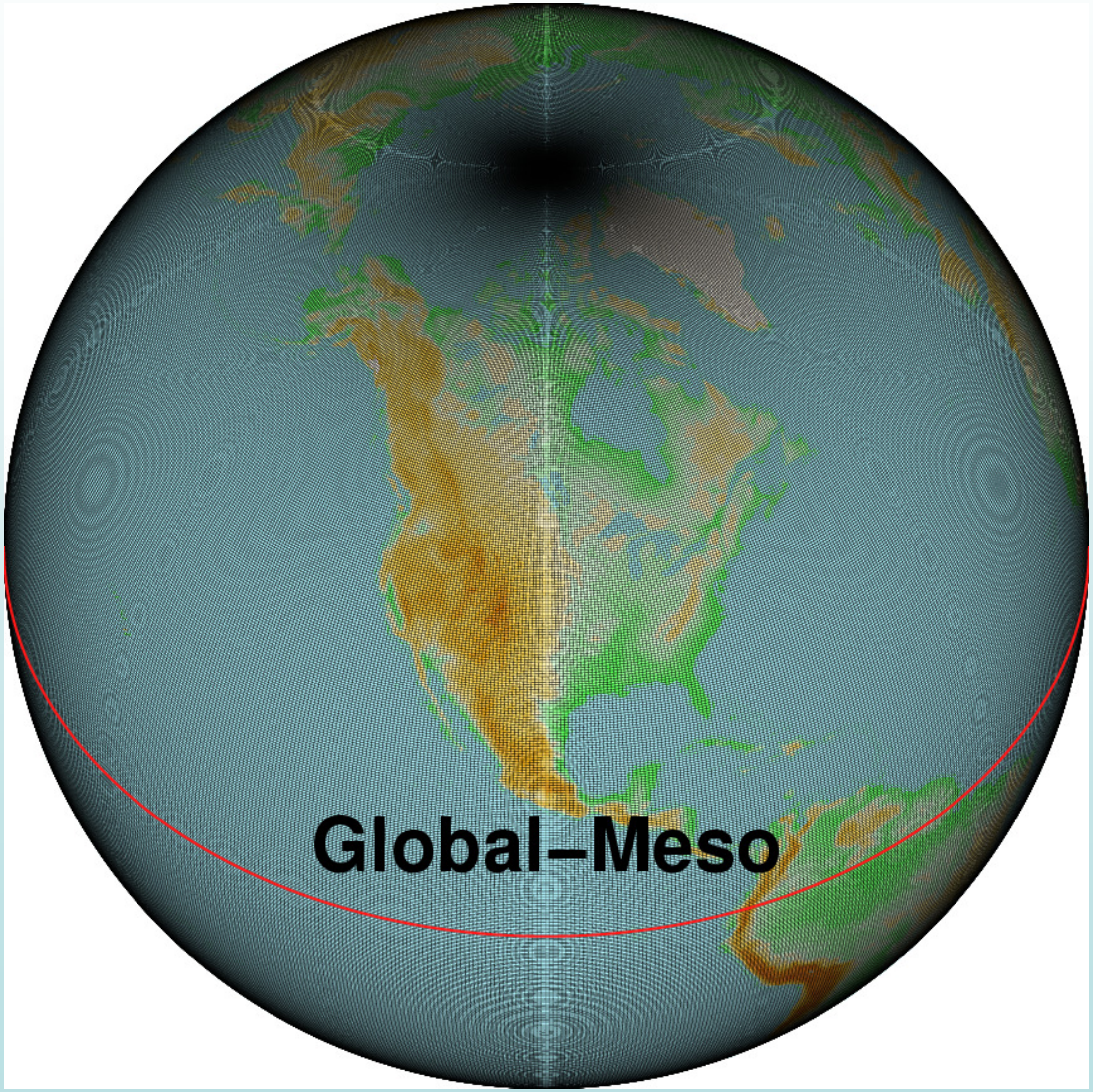
Data assimilation produces a best estimate of initial values by combining past information, carried forward in time by the model, with new observations using statistical techniques.

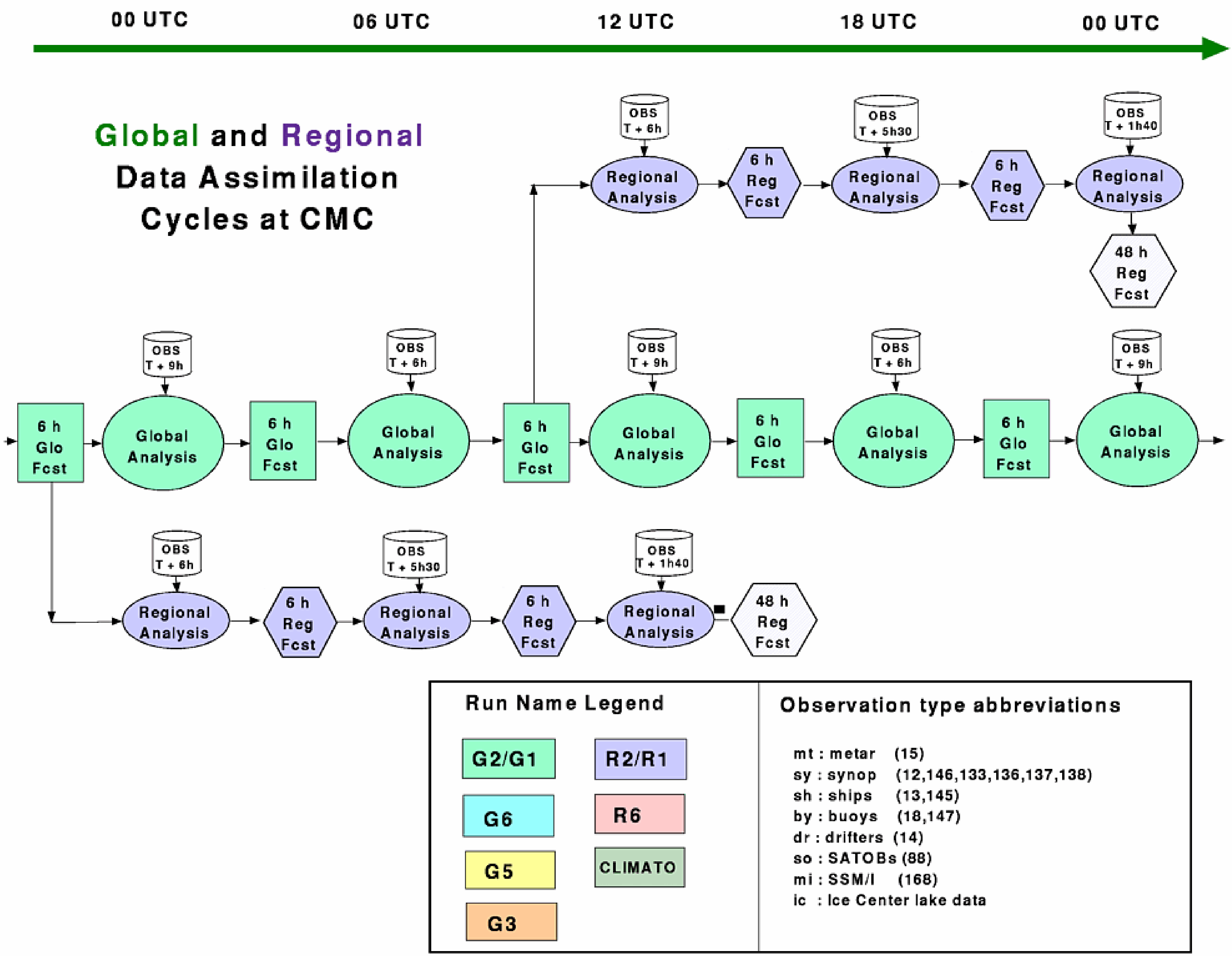
MSC's Data Assimilation and Prediction Infrastructure

- Global Environmental Multiscale Model (GEM)
- MSC operational forecast model, with development and operations based mostly in Dorval QC, running at Canadian Meteorological Centre (CMC)
- Multiple grid configuration (rotated/stretched lat-lon grid)

35 km Global GEM




00 UTC
06 UTC
12 UTC
18 UTC
00 UTC
Global and Regional
Data Assimilation
Cycles at CMC
OBS T + 6h
Regional Analysis
6 h Reg Fcst
OBS T + 5h30
Regional Analysis
6 h Reg Fcst
OBS T + 1h40
Regional Analysis
48 h Reg Fcst
OBS T + 9h
OBS T + 6h
OBS T + 9h
OBS T + 6h
OBS T + 9h
6 h Glo Fcst
Global Analysis
6 h Glo Fcst
Global Analysis
6 h Glo Fcst
Global Analysis
6 h Glo Fcst
Global Analysis
6 h Glo Fcst
Global Analysis
OBS T + 6h
OBS T + 5h30
OBS T + 1h40
Regional Analysis
6 h Reg Fcst
Regional Analysis
6 h Reg Fcst
Regional Analysis
48 h Reg Fcst
Run Name Legend
G2/G1
R2/R1
G6
R6
G5
CLIMATO
G3
Observation type abbreviations
mt : metar (15)
sy : synop (12,146,133,136,137,138)
sh : ships (13,145)
by : buoys (18,147)
dr : drifters (14)
so : SATOBs (88)
mi : SSM/I (168)
ic : Ice Center lake data

Statistical estimation: univariate case

X_b = forecast
(or background field)

y = observation

X_a = analysis

and X_t = true state

$\varepsilon_b = (\mathbf{X}_b - \mathbf{X}_t)$: **forecast error**

$\varepsilon_o = (\mathbf{y} - \mathbf{X}_t)$: observation error

$\varepsilon_a = (\mathbf{X}_a - \mathbf{X}_t)$: analysis error

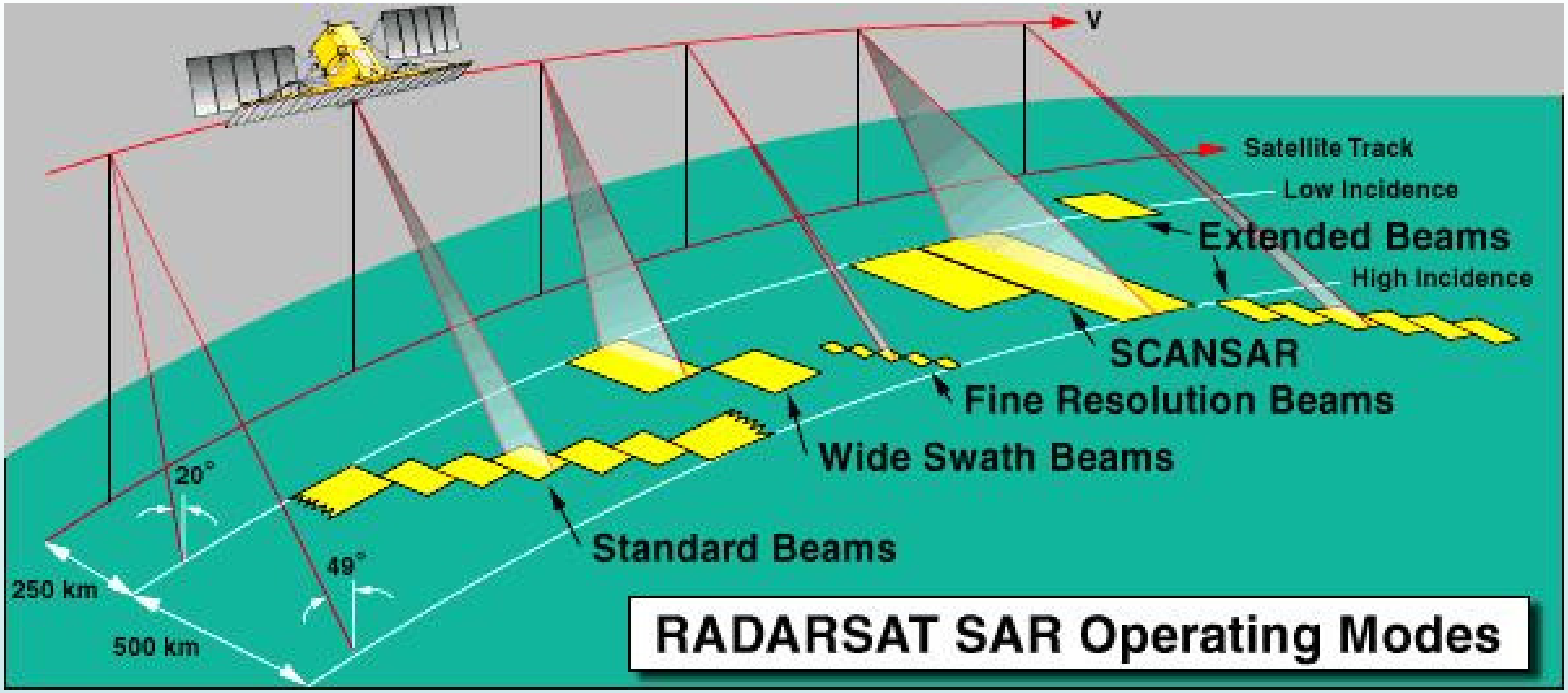
---

Analysis $$\mathbf{X}_a = (1-\lambda)\mathbf{X}_b + \lambda \mathbf{y}$$

$$\lambda = \frac{\sigma_b^2}{\sigma_b^2 + \sigma_o^2}$$

Surface Wind Validation using Radarsat

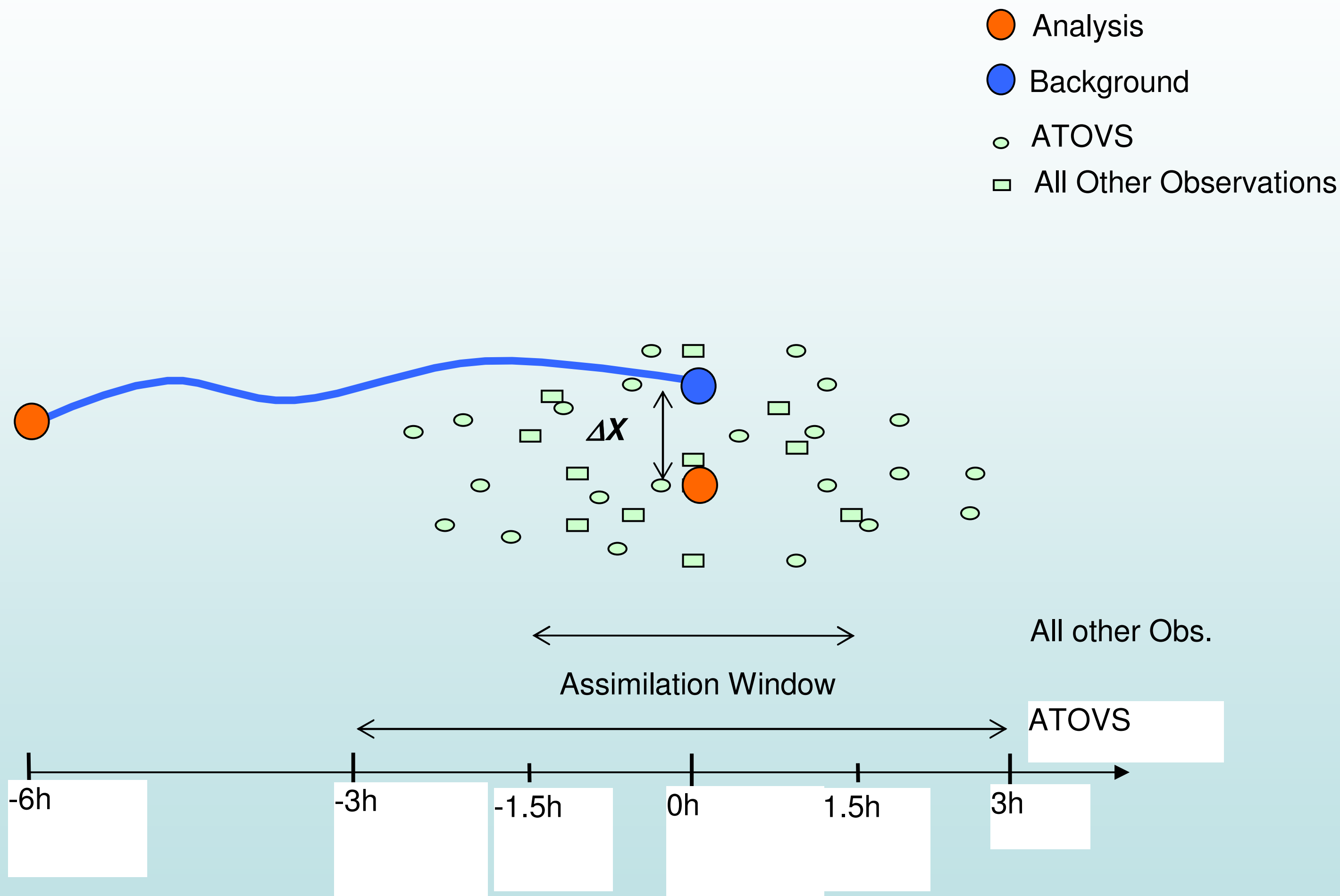
(Rick Danielson, Michael Dowd, Hal Ritchie)



Minimize the difference between our best guess fields versus GEM winds (x^b) and Radarsat obs (y)

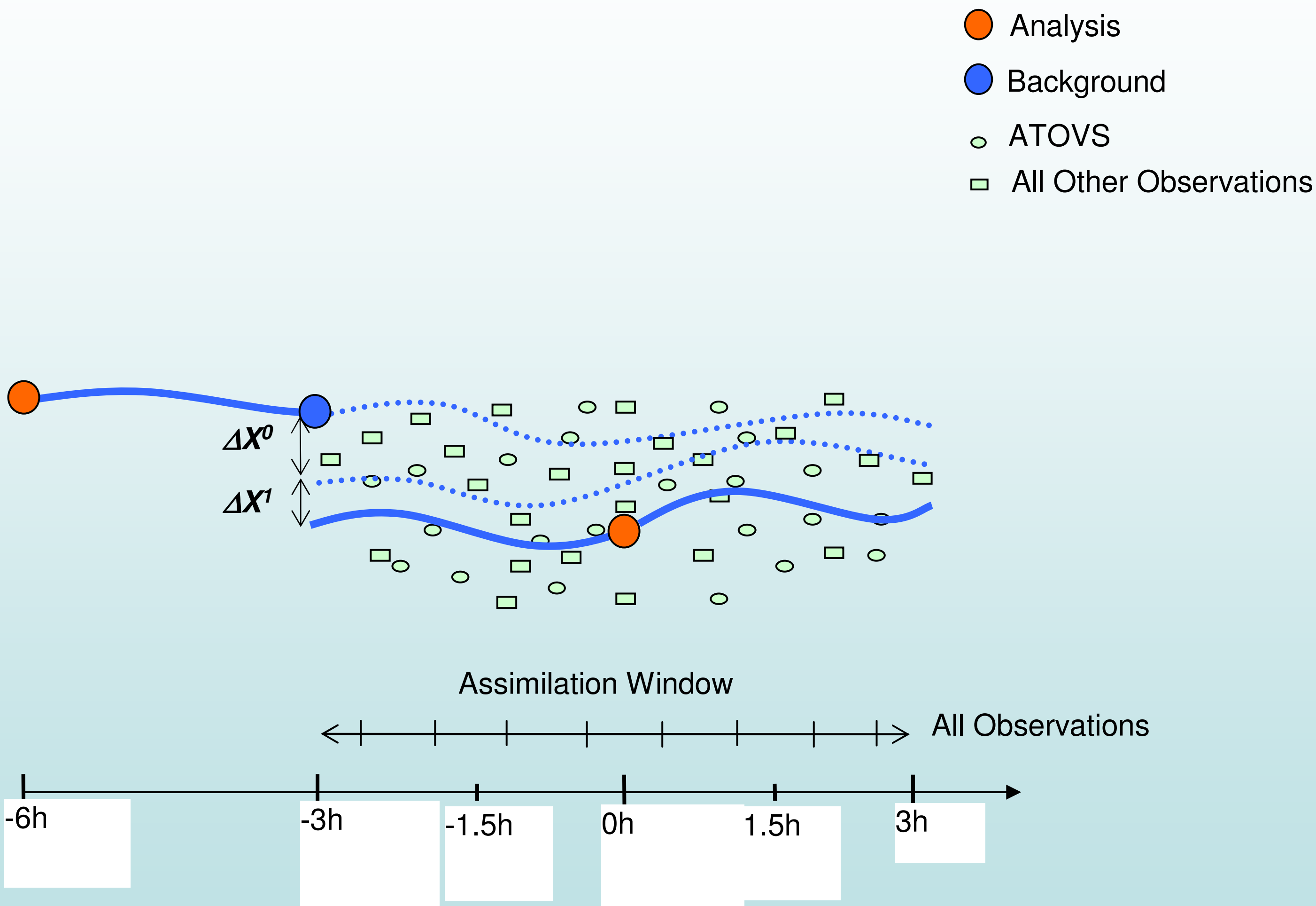
$$J(x) = \frac{1}{2}[\mathbf{x} - \mathbf{x}^b]^T \mathbf{B}^{-1} [\mathbf{x} - \mathbf{x}^b] + \frac{1}{2}[H(\mathbf{x}) - \mathbf{y}]^T \mathbf{R}^{-1} [H(\mathbf{x}) - \mathbf{y}]$$

3D-Var



Analysis
Background
ATOVS
All Other Observations
ΔX
Assimilation Window
All other Obs.
ATOVS
-6h
-3h
-1.5h
0h
1.5h
3h

4D-Var

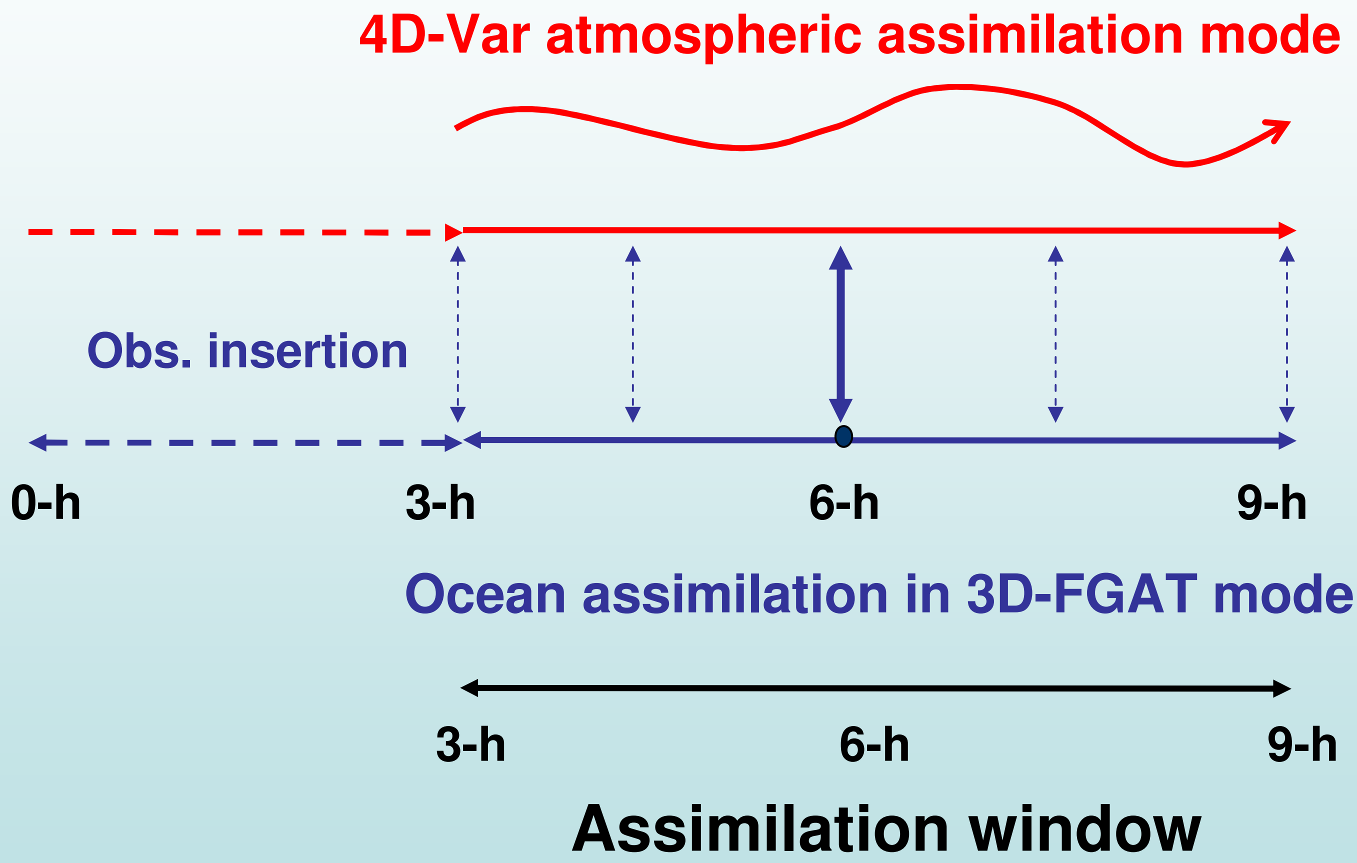


Analysis
Background
ATOVS
All Other Observations
ΔX⁰
ΔX¹
Assimilation Window
All Observations
-6h
-3h
-1.5h
0h
1.5h
3h

Development of a coupled atmosphere-ocean data assimilation system

- Assimilation of different lengths
  - Atmospheric 4D-Var uses a 6-h window
  - Oceanic analysis over a 7-day period (typically)
- Coupled model will run with a 6-h assimilation window
  - Oceanic assimilation will benefit of having a shorter assimilation because
    - Analysis will be closer to the obseration time
    - Smaller analysis increments which tend (usually to reduce spin-up problems)
- The background state will be produced with the fully coupled model
  - Coupling will come in through the model integration over the length of the assimilation cycle (months to years)

Schematic of a coupled atmosphere-ocean data assimilation scheme



First objectives

- Develop and test the assimilation for the coupled GEM-NEMO system
  - Monitoring of observations to detect if biases are developing
  - Diagnosis of the analysis increments is also a good indicator if biases are emerging
- First assessment of the coupled background error covariances
  - Variability of free coupled-model integration could provide a first estimate of these interactions
  - Results from the assimilation system could be used as a next step to reevaluate these couplings.

I.2.1 Independent Assimilation into Coupled Models - Objectives

- Initially improve A & O forecasts when driven "off-line" by analyses from uncoupled DA cycles of the other component (benchmark for later coupling)
- Further improve A & O forecasts when component models are coupled during background forecasts, not analysis step
- Provide coupled A-O fields from coupled A-O hindcasts for subperiods of 1993-2005, to be used in project I.2.2.

Schedule & Milestones

- Years 1-2: Perform atmosphere-only DA and forecasts for periods during ocean-only forecast being done in I.1.4 (ocean reanalysis & forecasting); establish atmospheric verification metrics; compare with I.1.4 (uses NCEP forcing); establish ocean verification metrics
- Years 3-4: Redo analyses & forecassts using independent DA; compare with previous results; perform initial coupled DA hindcasts for sub-periods of 1993-2005; examine how sensitivity to observations is affected by marine boundary layer parameterizations

I.2.2 Exploratory Studies on Joint Assimilation into Coupled Models

- Objective: examine A-O cross-correlation functions during analysis step, i.e. joint A-O DA
- Years 1-2: Evaluate A-O cross correlations based on long CGCM run from II.1.1 (tropical modes), set up & evaluate simplified coupled A-O GEM-OPA system, perform control simulation for twin experiment
- Years 3-4: Use "NMC method" to determine cross-correlation functions; perform joint DA & evaluate impacts; examine predictability as a function of variable, time-scale, season & region cf outputs from I.2.1

Current status

- PDF being hired for I.2.1 at UQAM
- For I.2.2, a 250-year control run based on the most recent version of CGCM3 (T63, no flux adjustment, new ocean physics) is underway and should be completed soon. Merryfield is working with CCCma's AGCM group to reduce biases in CGCM4. A long CGCM4 control run will be undertaken when that work has reached a suitable stage.
- Merryfield and GOAPP RA W.-S. Lee have begun developing software tools for evaluating cross correlations in the CGCM.
- PDF Faez Bakalian started at Dal July 1, 2007 and is making very good progress for I.2.2