Environment Canada Environnement Canada

Fisheries and Oceans Canada

MERCATOR OCEANOGRAPHIC OPERATIONNELLE

Canada

Coupled Air-Sea-Ice-Wave Modelling

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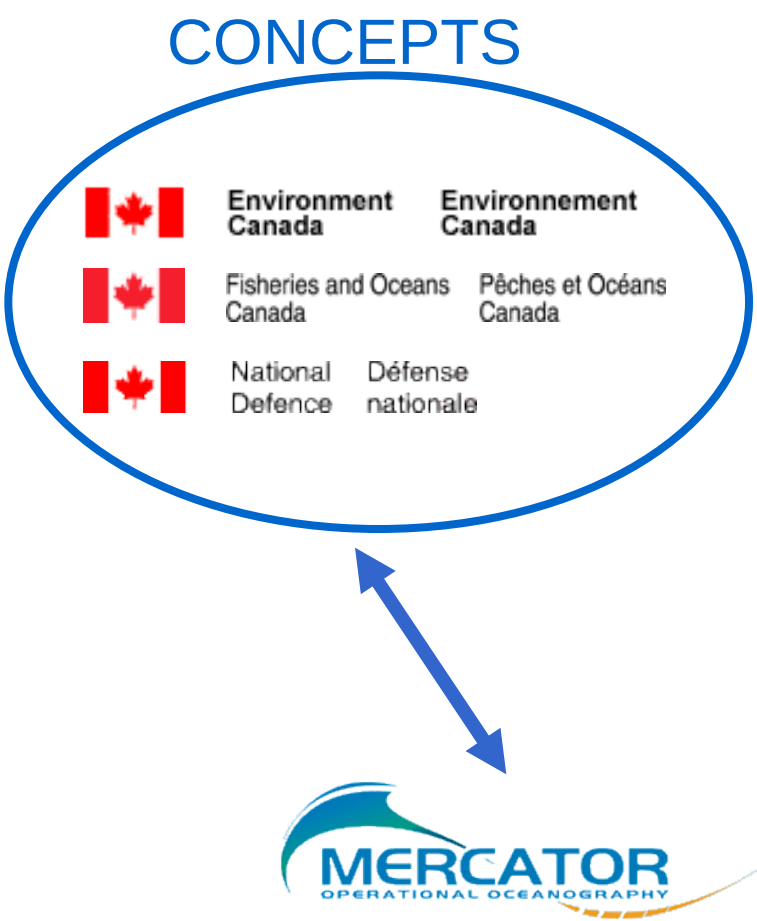
MEOPAR IP1.1 & IP 1.2 Science planning meeting, Halifax, 23-24 January, 2013

CONCEPTS

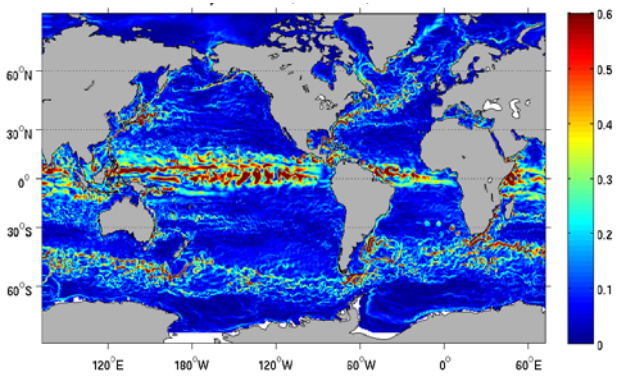
- Several new coupled systems under development as part of CONCEPTS
  - Canadian Operational Network of Coupled Environmental Prediction Systems
- Tri-departmental collaboration
  - To develop coupled atmosphere-ice-ocean forecasting systems
- Model development
  - Coupling the GEM (Global Environmental Multi-scale) atmospheric model to NEMO (Nucleus for European Modelling of the Ocean)
- Collaboration with Mercator
  - French operational oceanographic group



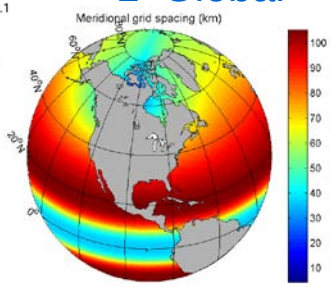
Ice-ocean modelling using NEMO

- Global 1/4° resolution
  - Medium range forecasting
- Global 1° resolution
  - Monthly-to-seasonal forecasting
- N. Atlantic and Arctic 1/12°
  - Short-to-medium regional forecasting
- Great lakes 2km
  - Short term forecasting

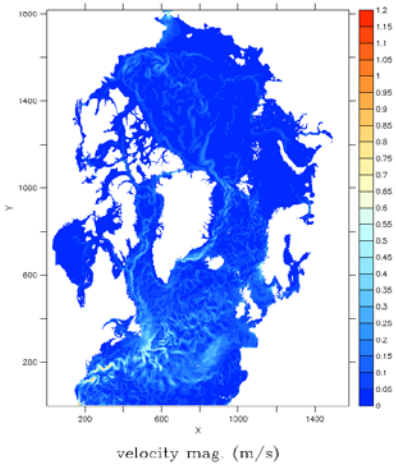
1/4° Global

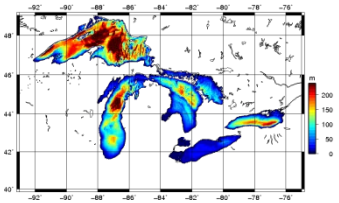


1° Global



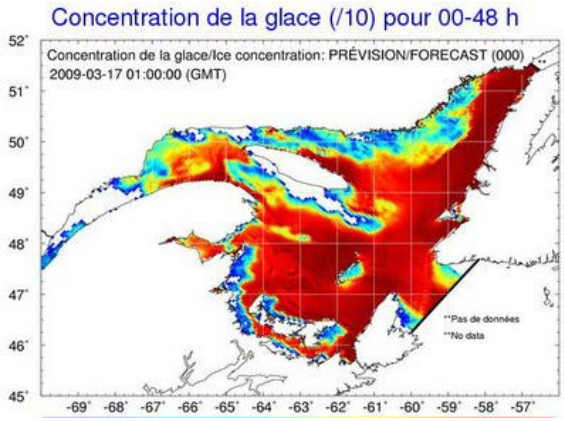
1/12° N. Atlantic and Arctic





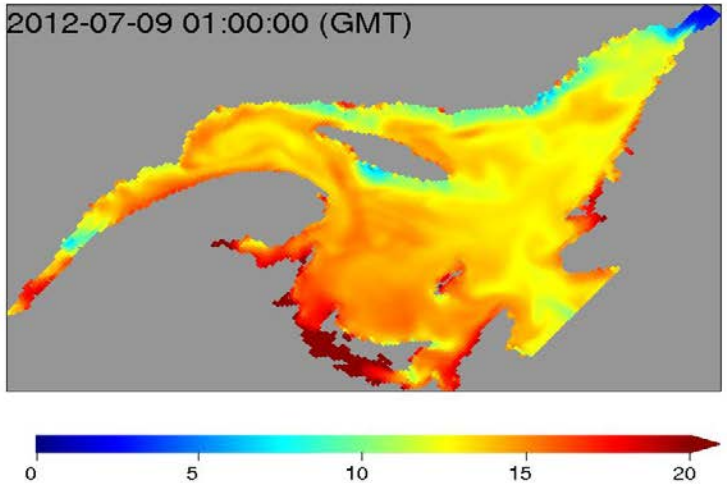
Coupled Atmosphere-Ice-Ocean Forecast System for the Gulf of St. Lawrence

- Initiated 14 years ago by the Maurice Lamontagne Institute (IML-DFO) and Recherche en Prévision Numérique (EC)
- EC and DFO have successfully developed a fully-interactive coupled atmosphere-ice-ocean forecasting system for the Gulf of St. Lawrence (GSL).
- This system has been running operationally at the Canadian Meteorological Centre (CMC) since June 2011.
- NEMO is replacing the IML model and case studies are in progress.

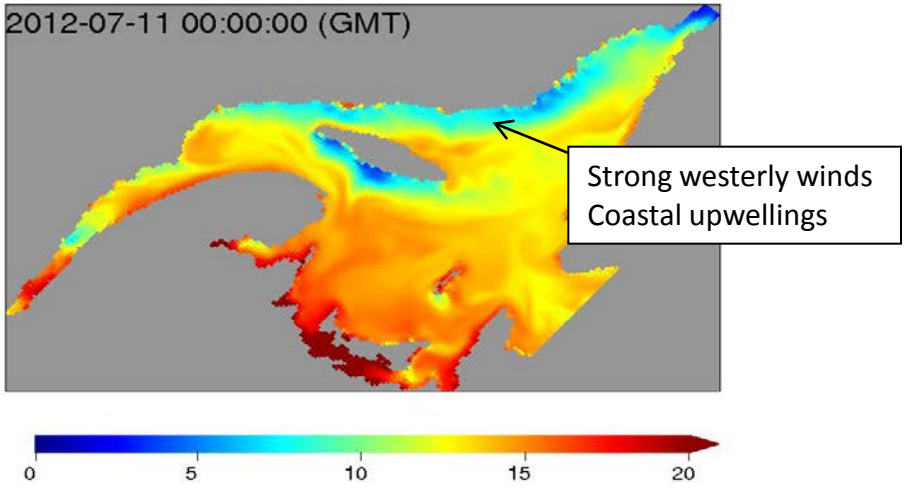


GEM-NEMO coupled in the Gulf of St. Lawrence
Case study of an upwelling event

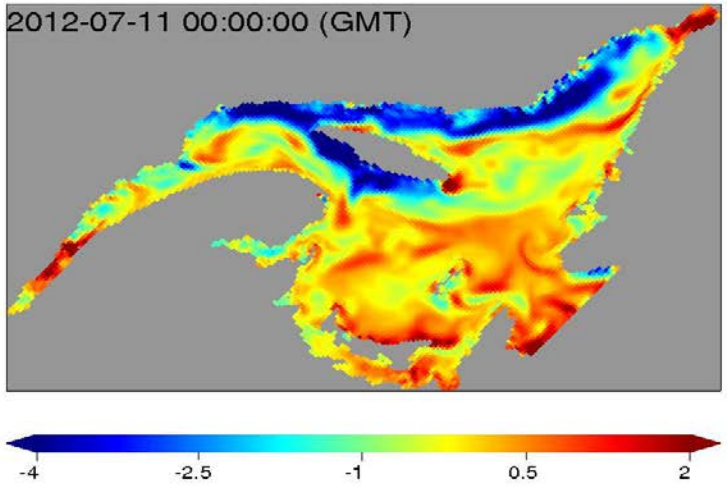
SST analysis



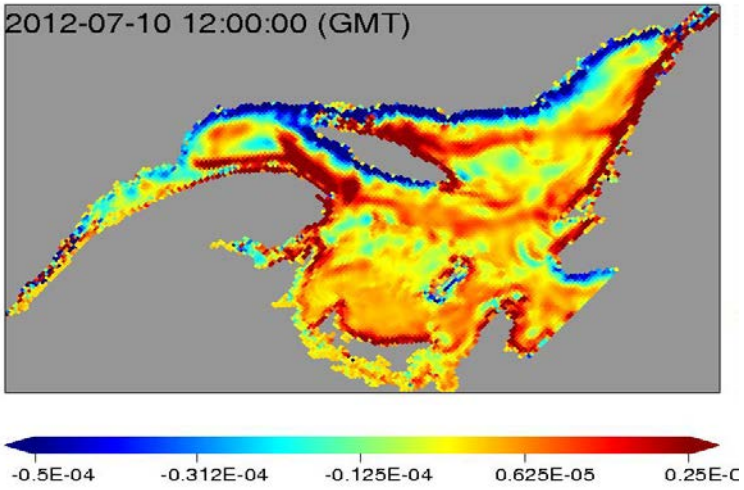
48h SST forecast (GEM-NEMO)



48h change in SST

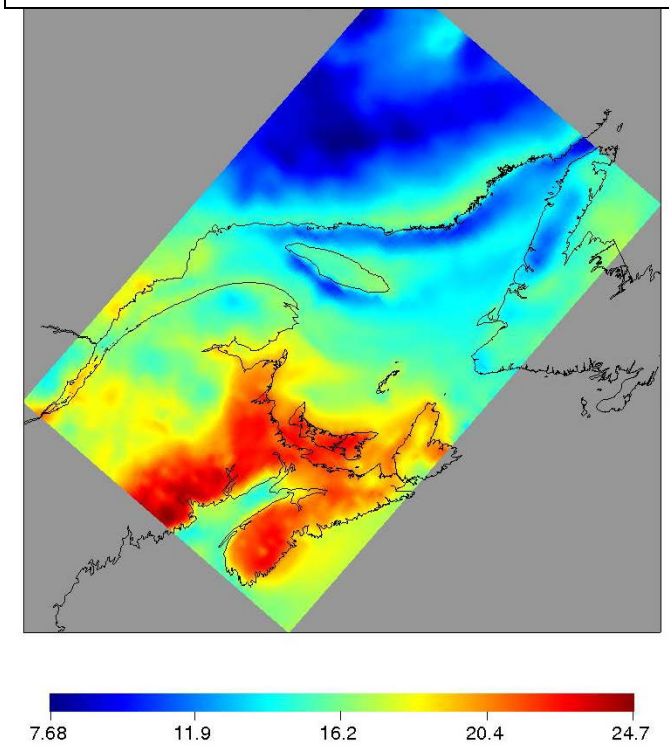


-W (vertical velocity) (0-30m)

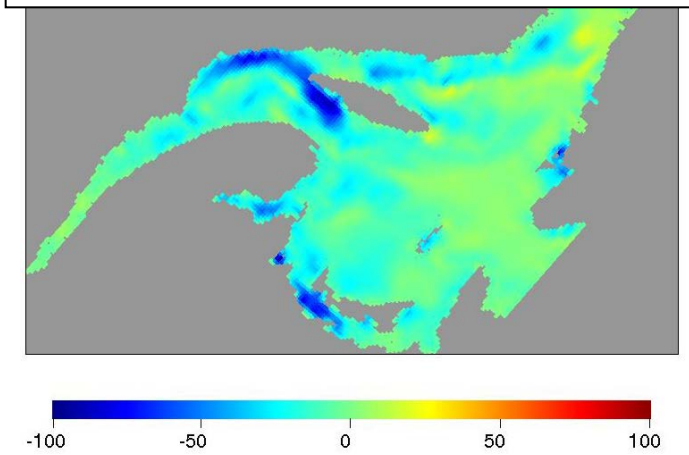


Impact of adding a dynamic SST in the weather forecast instead of keeping it constant

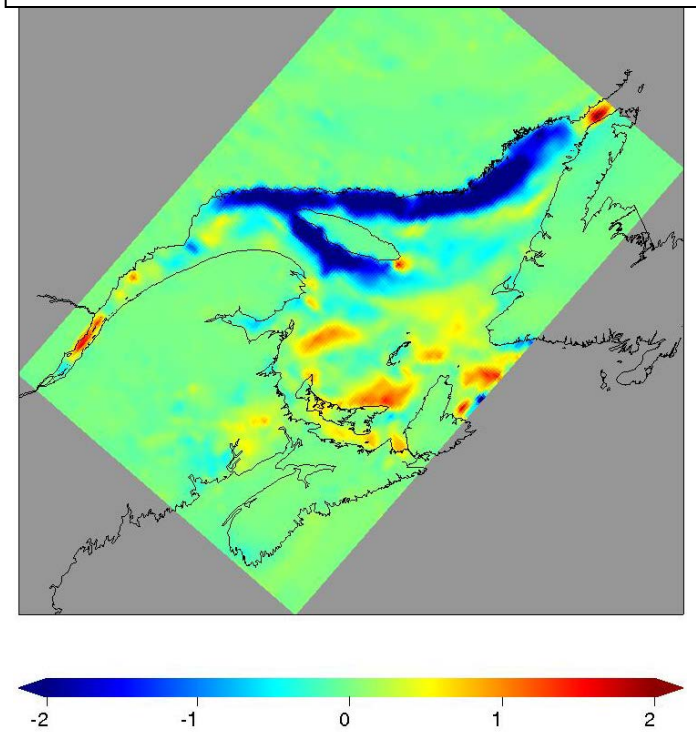
Air temperature 48 h forecast



Averaged latent heat flux difference (0-48 h)



Air temperature difference at 48 h



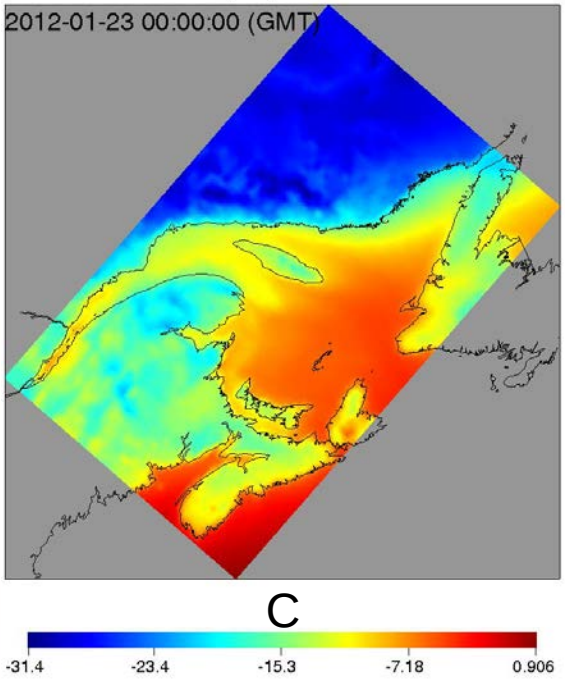
GSL experimental GEM-NEMO coupled system

Case study (January 21 2012)

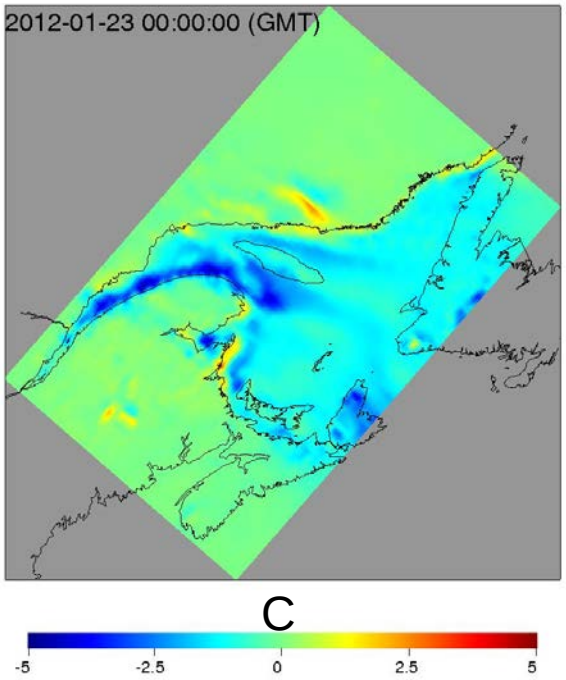
Impact of having an evolving instead of fixed ice cover

48 h air temperature forecast

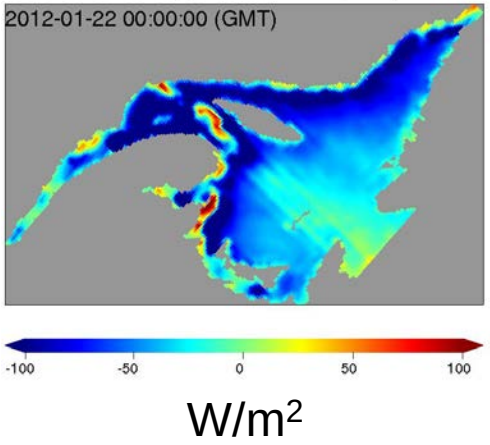
with evolving ice cover



evolving – fixed ice cover

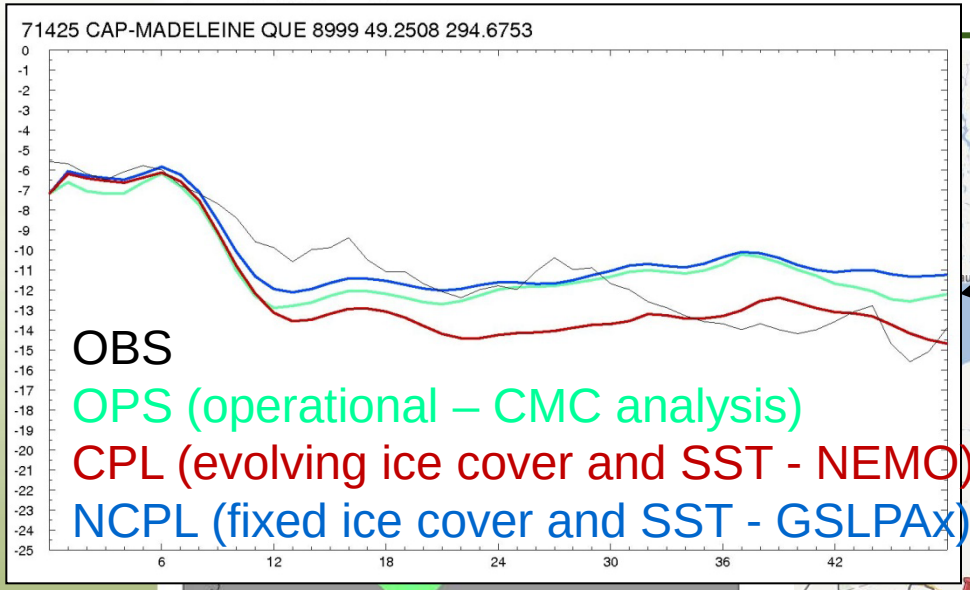


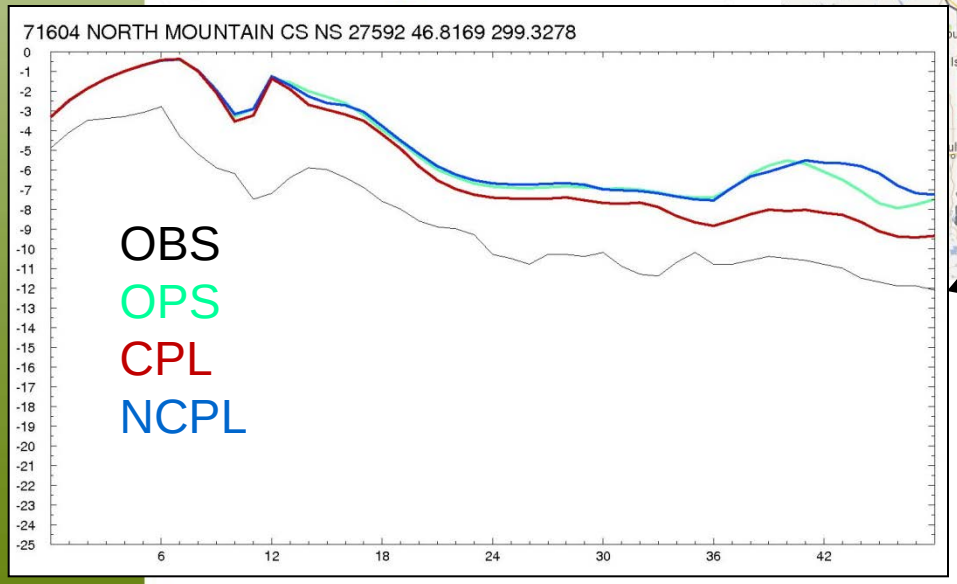
Impact on 48 h averaged sensible + latent heat flux

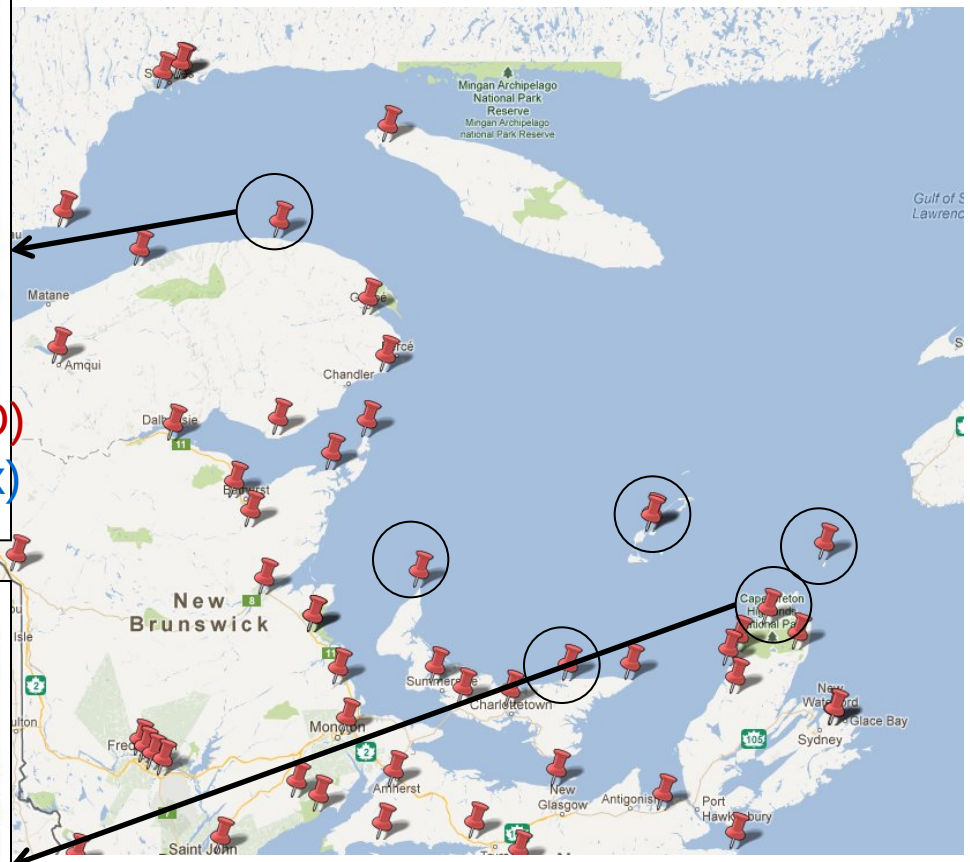


GSL experimental GEM-NEMO coupled system

Case study (January 21 2012)



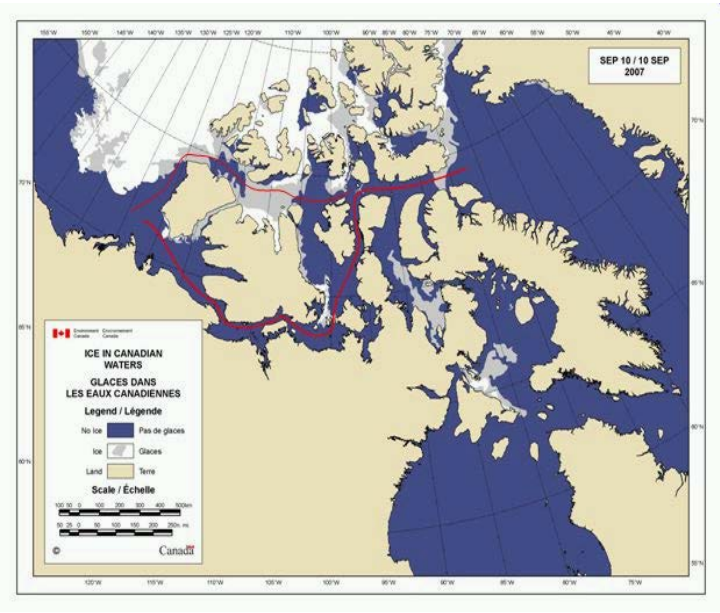




Canada

Environment Canada (EC) METAREAs Initiative: Backgrounder

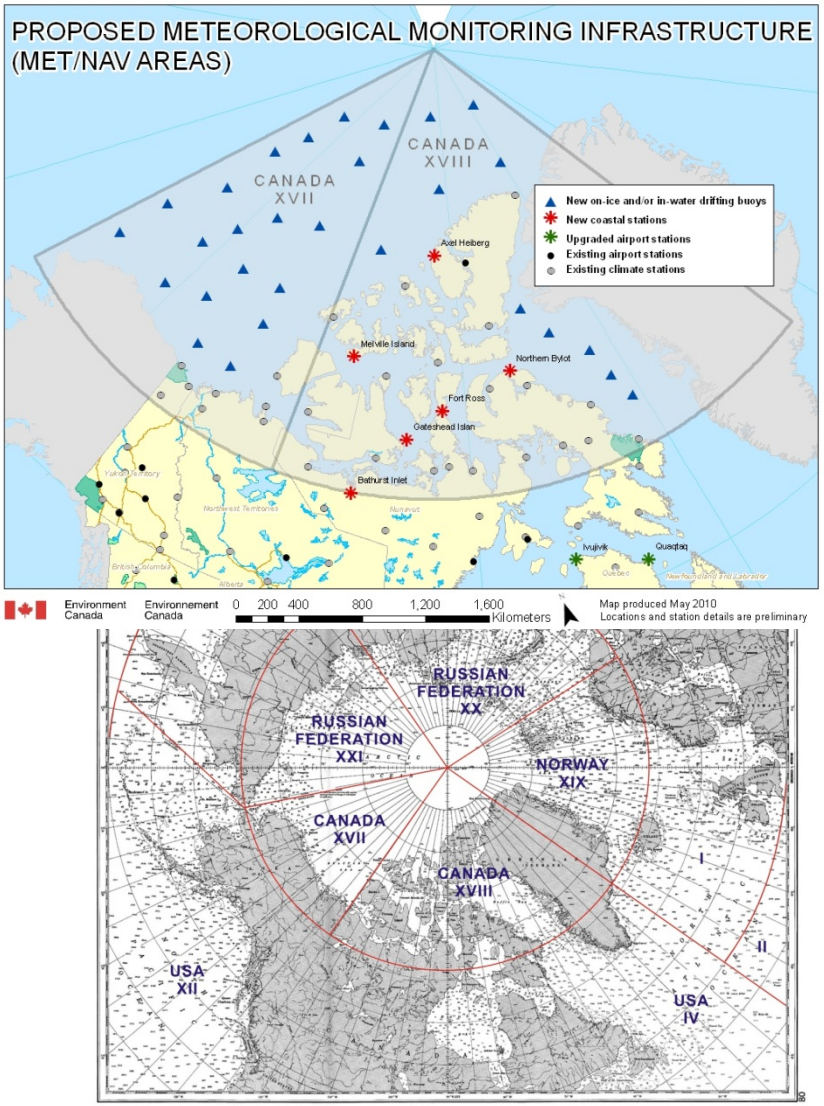
- Decreasing Arctic ice cover has resulted in an increase in navigable Arctic waterways.
- In anticipation of increased marine traffic, the International Maritime Organization established 5 new METAREAs covering the Arctic.
- In 2007, EC & the Department of Fisheries & Oceans (DFO) expressed Canada's willingness to become an Issuing Service for METAREAs XVII & XVIII.
- In July 2010, EC commenced issuing meteorological Maritime Safety Information for these areas on a test basis.



April 2007

EC's involvement in METAREA's

- **Development of an integrated marine Arctic prediction system in support of METAREA monitoring and warnings.**
- **Development of short-term marine forecast system using a regional high resolution coupled multi-component modelling (atmosphere, land, snow, ice, ocean, wave) and data assimilation system**
- **To predict:**
  - **Near Surface atmospheric conditions,**
  - **Sea ice (concentration, pressure, drift, ice edge)**
  - **Freezing spray,**
  - **Waves, and**
  - **Ocean conditions (temperature and currents)**
- **Improved Arctic monitoring**



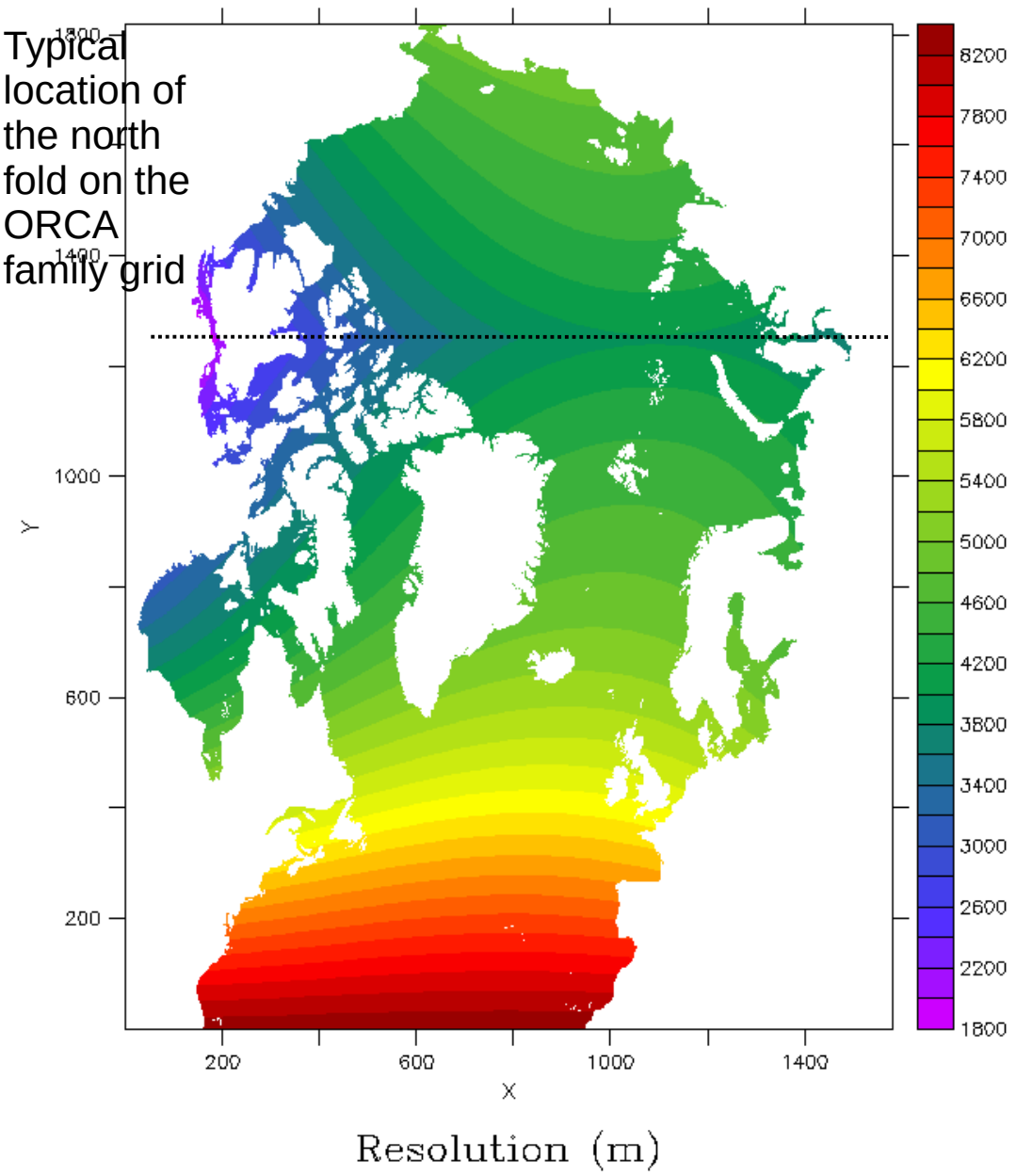
Ocean-Ice Model Domain: 1580x1817x50 512 procs (271 land procs removed)

CREG12: Regional CONCEPTS domain. Extracted from ORCA12 (Mercator) with the north fold stitched back.

Run 4 days in 23 minutes (1 year in 1.5 day). Hindcast only so far

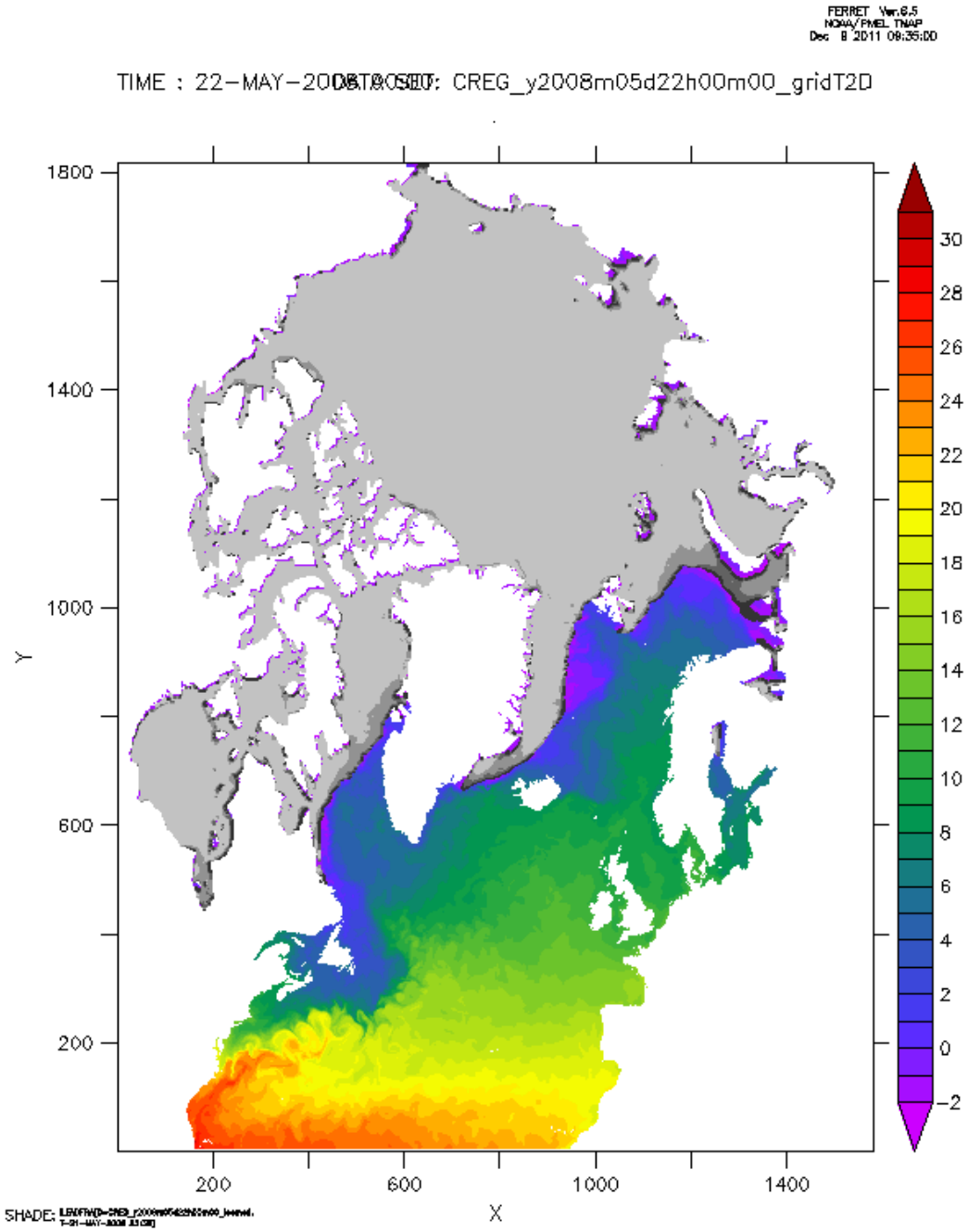
Resolution is finest near the artificial pole over northern Canada at 1.8 km and coarsest along the Atlantic northern boundary (8.2km)

Covers part of North Atlantic (27N), the whole Arctic Ocean.



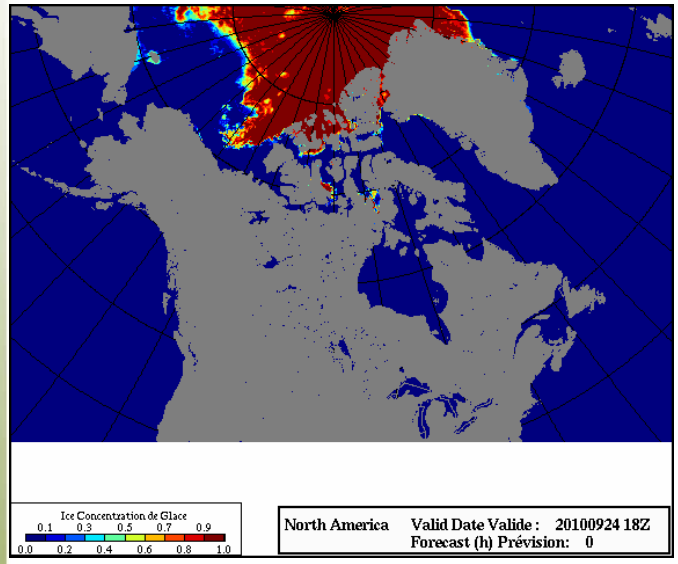
CREG12 Development Work

- Produced 2 8-year free-runs of CREG12 with NEMO-LIM
- Preliminary results look reasonable
- Can now run NEMO coupled with CICE ice model
- CREG12 with tides being tuned.
- Hindcasts with NEMO-CICE in progress
- Historical forecasts with CREG soon

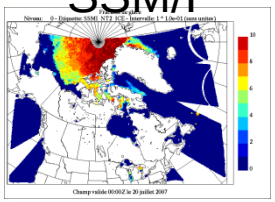

FERRET Ver.6.5
NOAA/PMEL TMAP
Dec 8 2011 09:35:00
TIME : 22-MAY-2008 00:00:00
SHADE: CREG_y2008m05d22h00m00_gridT2D
1800
1400
1000
600
200
Y
200
600
1000
1400
X
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
−2
Temperature (C)

CIS/MRD Sea-ice Analysis System (3Dvar FGAT persistence first guess)

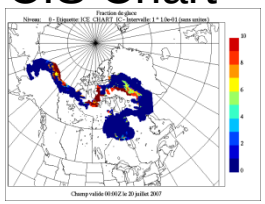
M. Buehner, T. Carrieres, L. Pogson, A. Caya, …



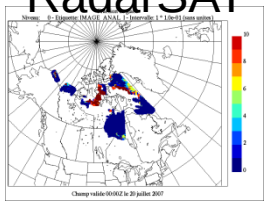
SSM/I



CIS Chart

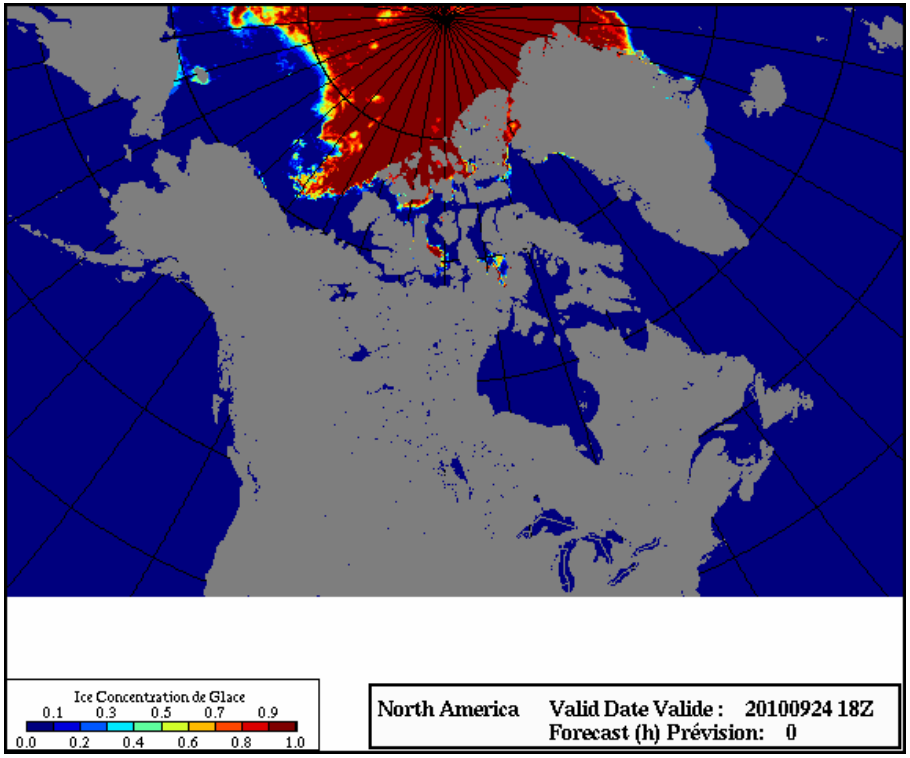


RadarSAT



- North American Analysis:
  - Four analyses per day of ice concentration at 5 km resolution
- Global Analysis:
  - two analyses per day on 10km grid
- Currently assimilates:
  - SSM/I, CIS daily charts, Radarsat image analyses
  - Operational since March 2011
- Work in progress to add:
  - SSMIS, scatterometer, visible-infrared, SAR and ice thickness satellite-based observations

METAREA Regional Ice Prediction System (RIPS)



- 4 - 48hr forecasts per day:

  -CICEv4.1 forced by CMC RDPS

  -5km North American grid

- Initialized with 3DVar ice concentration Analysis (00Z, 06Z, 12Z and 18Z).
- Also initialized with

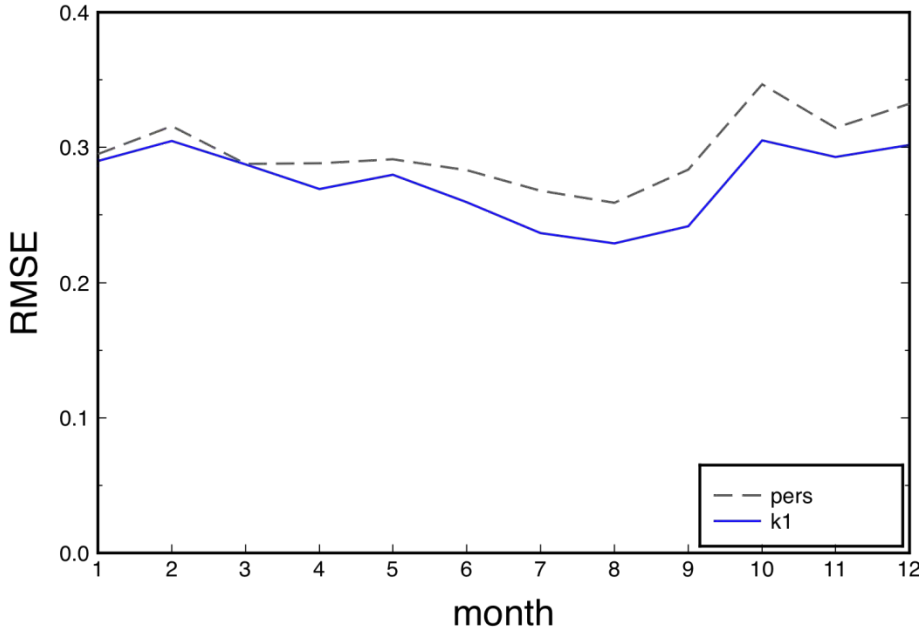
  -CMC operational SST analysis

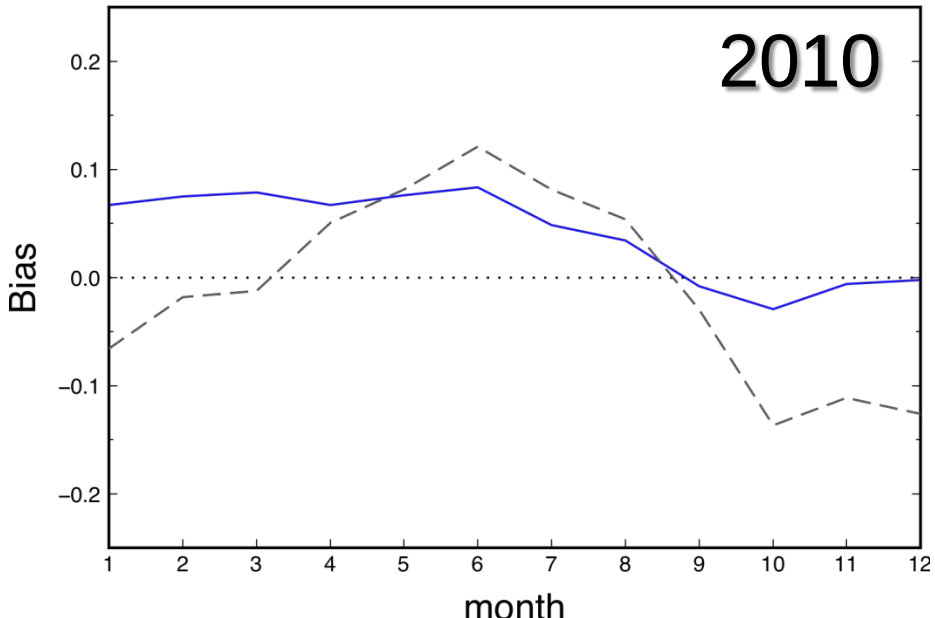
  -Mercator Glorys1v1 thickness climatology

  -Glorys1v1 mixed layer depth climatology

  -Glorys1v1 ocean current climatology

RIPS validation against 3Dvar (monthly stats)





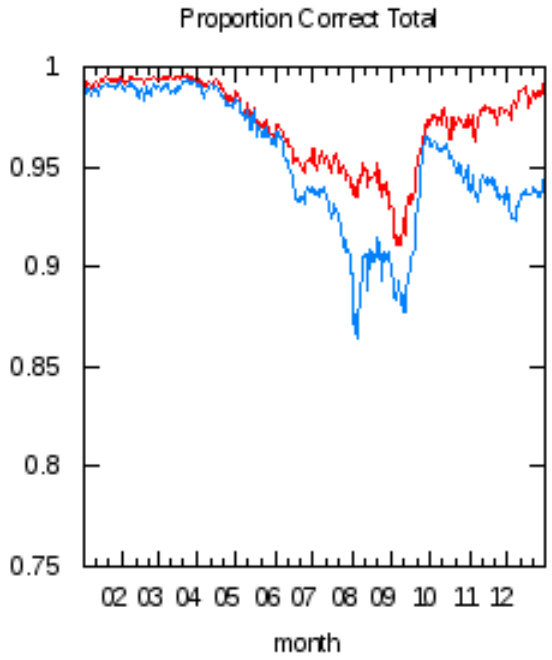
Better than persistence for all the months but not statistically significant in January and March.

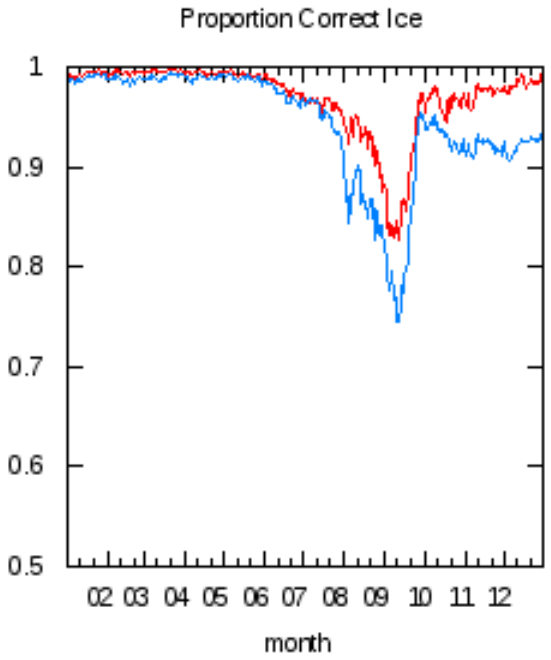
Regional Ice Prediction System

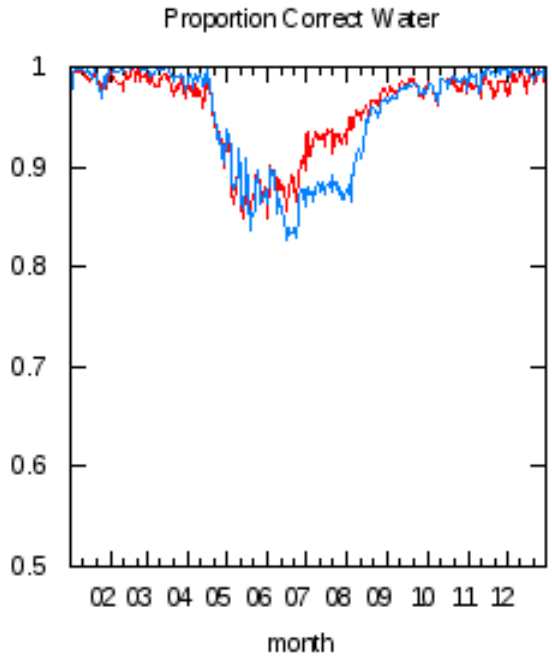
- RIPS 2.0 (~Jan 2013):
  - Additional observations:
    - SSM/IS (DMSP16-17-18)
    - ASCAT (1 satellite)
  - Assimilation of all satellite data over lakes
  - A new analysis-error standard deviation field for ice concentration
  - Sea ice model CICE4 is used to produce short-term forecasts (lead time up to 48 hours)

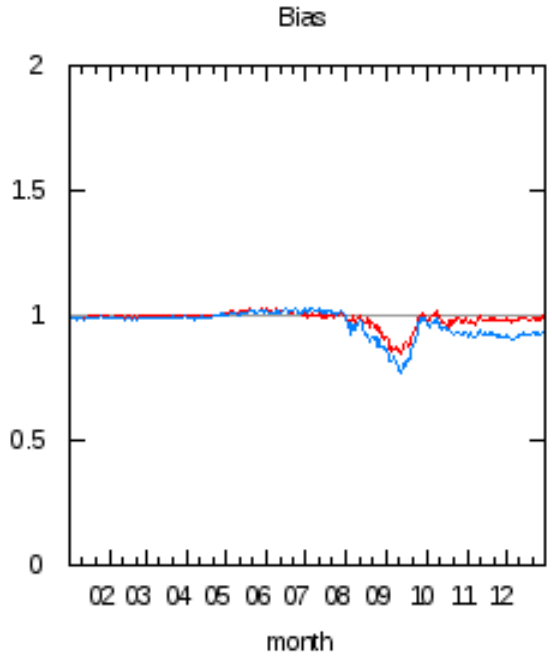
All Arctic

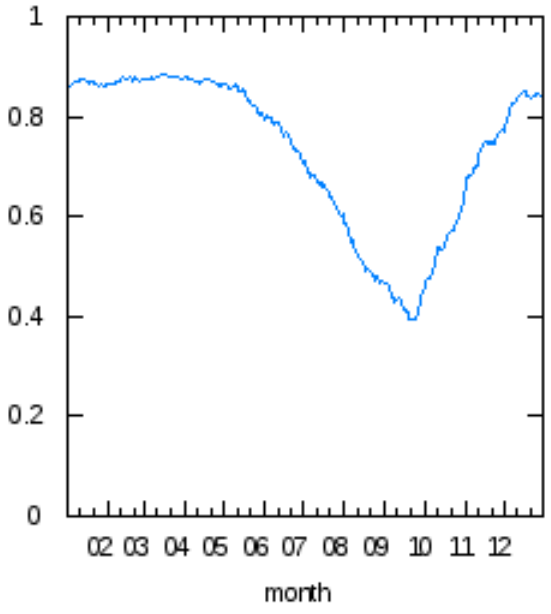
North of 65°N

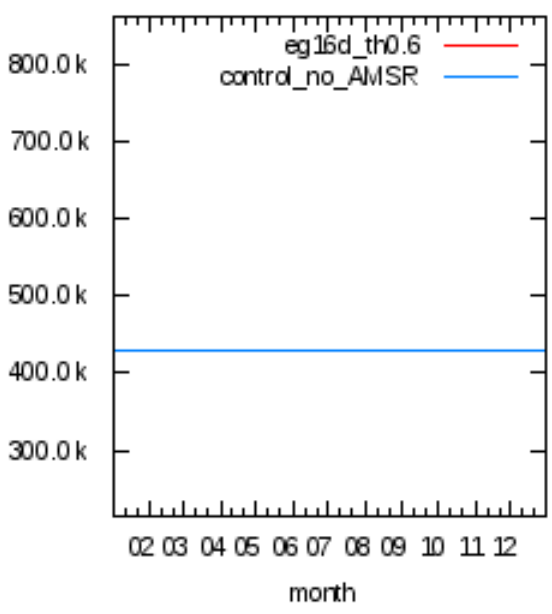






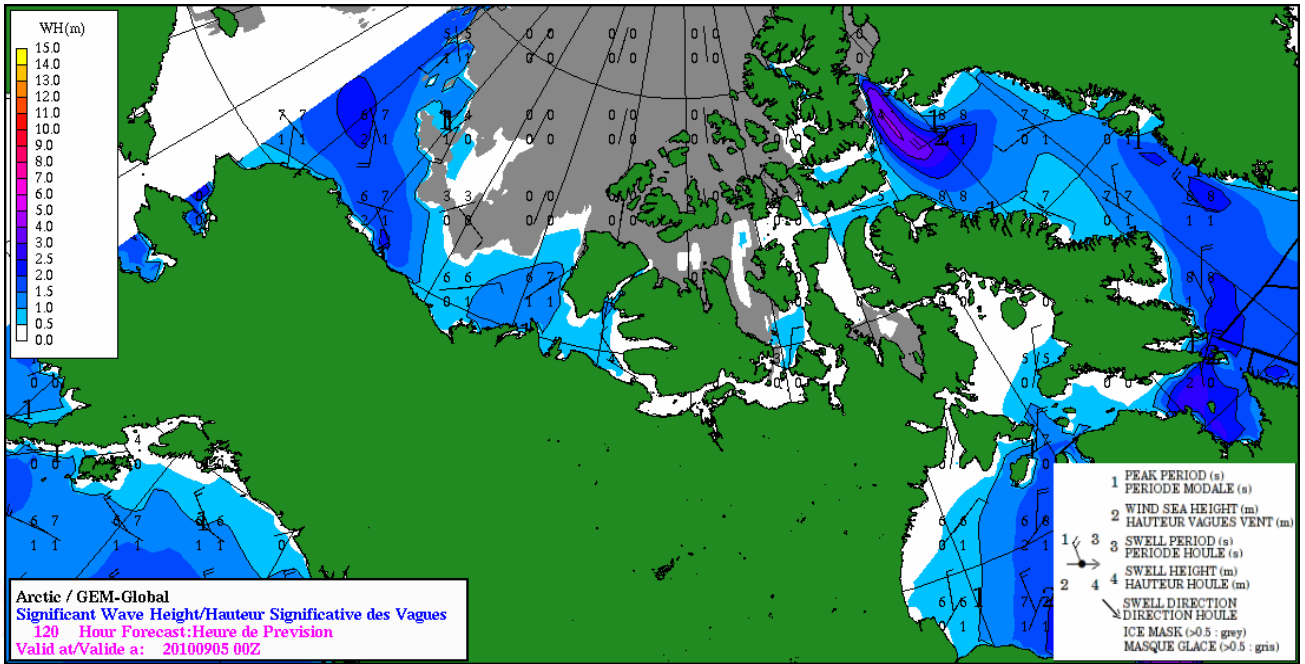






Wave model- Arctic Domain

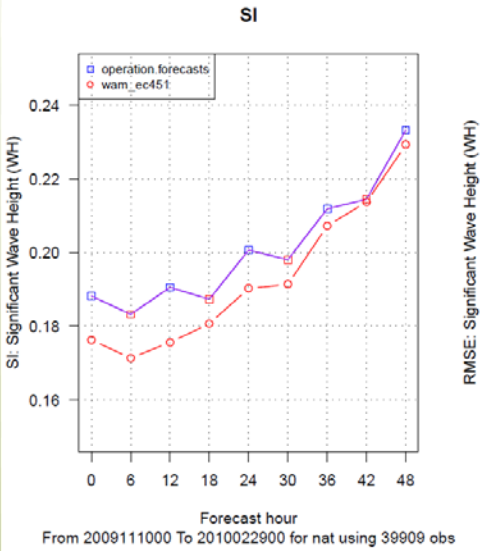
- Regional Arctic domain operational with WAM-EC 4.5.1 implementation on May 7/2012.
- Arctic domain is a lat/lon rectangular grid (0.4x0.8 degree resolution) from 49N to 85N and from 45W to 165W
- Arctic domain forced with 10m winds from GEM-Regional (4x/day to 54 hrs) and by GEM-Global (2x/day to 120 hrs)
- Ice mask is stationary and supplied by the CMC regional and global analyses
- Model outputs (sig. wave height) are feeding both the regional and global Scribe Marine Matrices

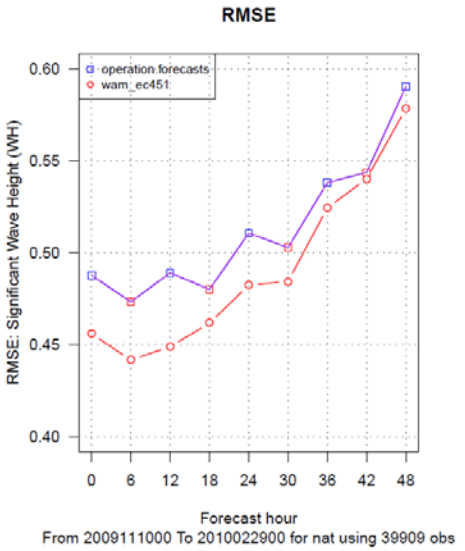


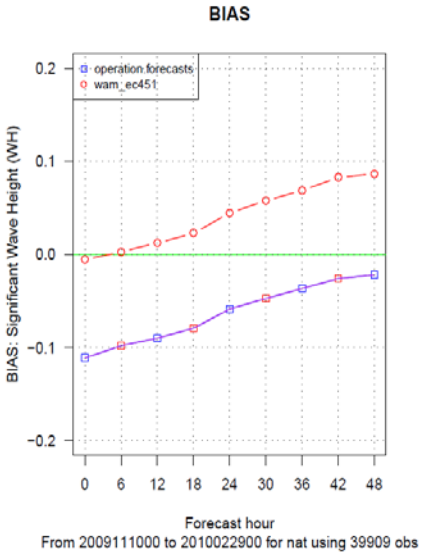
Canada

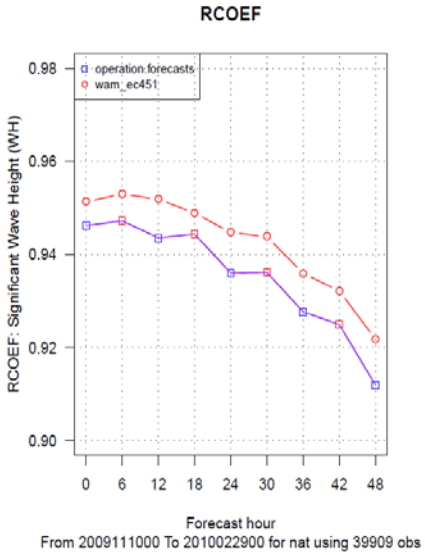
Objective Verification Highlights
North Atlantic (NAT-Reg)

- Winter 2009/2010





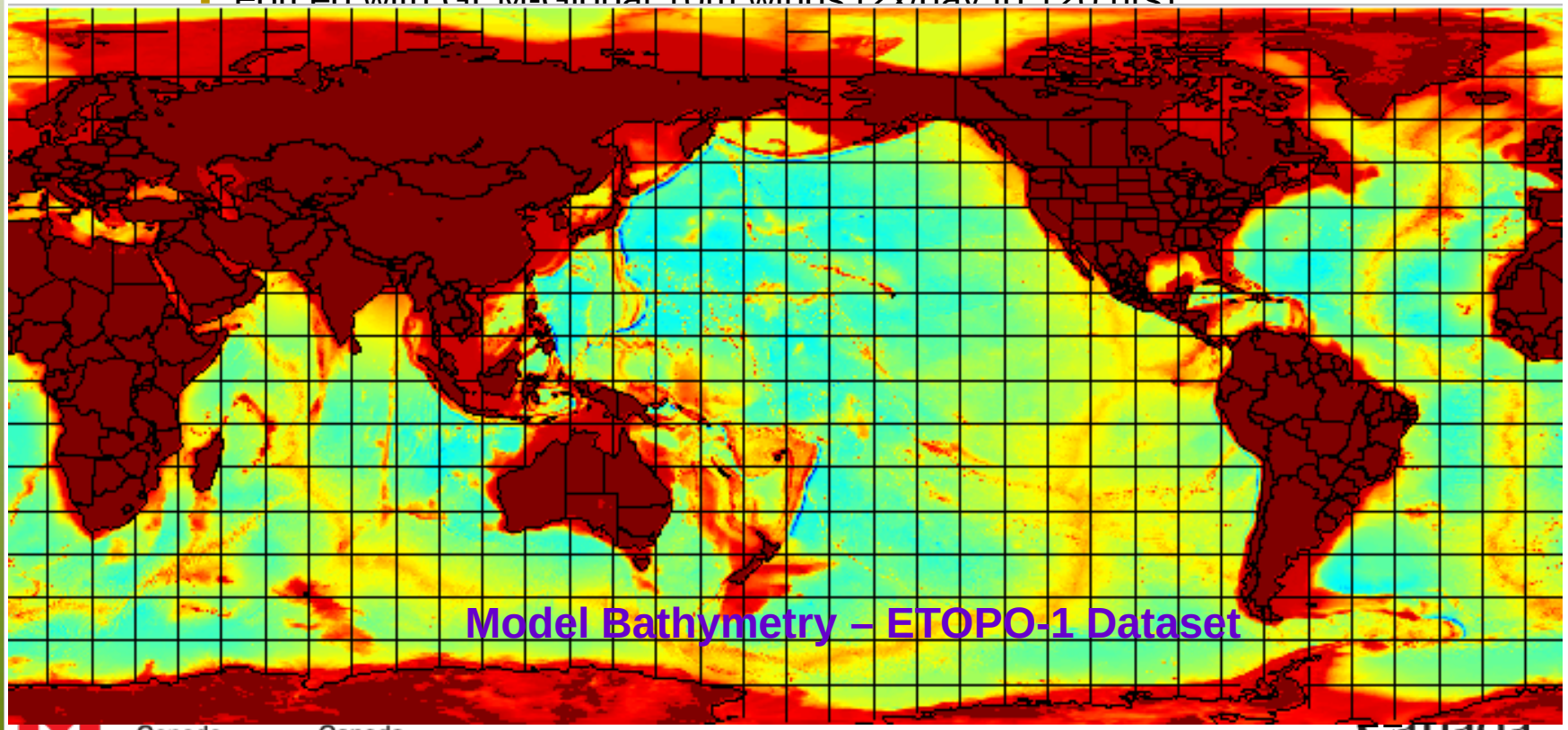




BUOYS USED:
41001,41010,41025,41047,41048,41049,44005,44007,44008,44009,44014,44017,44025,44066,

CNWP – Wave Update – (2012-2013)

- R&D
  - Model Migration from WAM to **WaveWatch3 (WW3)**
  - Introducing WW3 through a **global wave model system (GDWPS)**
    - Global domain in development (covers 80S to 86.2N) at a resolution of 0.20x0.20 degrees
    - Forced with GEM-Global 10m winds (2x/day to 120 hrs)



CONCEPTS Global Ice-ocean forecasting system

Medium-range Coupled Global Prediction System

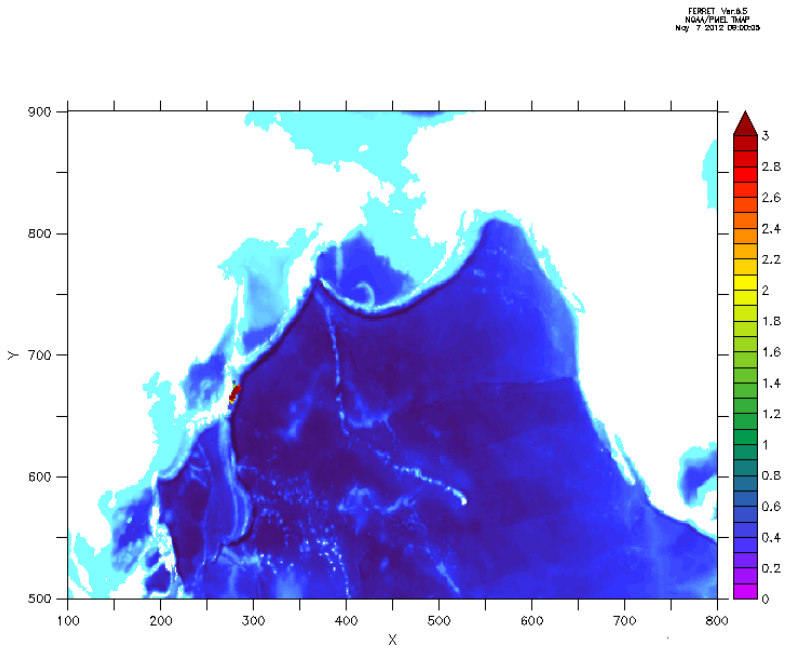
- Aims:
  - Improve 10day deterministic weather forecasts
  - Backbone for other CONCEPTS systems
    - Boundary conditions for regional system, wave model
    - Global conditions available for emergency response (e.g. DND)
- Description:
  - Based on Mercator operation system (ORCA025 with SAM2)
  - Also constrained with CIS/MRD 3DVAR ice analysis
  - Coupled to 33km (25km) GEM global
- Status:
  - Routine production of weekly ice-ocean analyses since Dec. 2010 – to implement operationally by March 2013
  - Evaluation of ice-ocean forecasts underway (results comparable to RIPS to 48-hours, always beats persistence beyond)
  - Starting initial evaluation of coupled runs
  - Mercator monitoring system being installed

Summary & conclusion

- Early systems have matured and are being implemented operationally.
- Regional systems are converging on a coupled GEM-NEMO framework for application in a variety of Canadian regions, with the Arctic as a major focus.
- An initial global ice-ocean forecast system has been developed and evaluated.
- A coupling-ready global ice-ocean data assimilation and forecast system has been developed and preliminary assessments of ice-ocean forecasts and coupled GEM-NEMO forecasts are underway.
- These systems provide the starting point for our MEOPAR coupled modelling.

Merci!

- Main contributors & collaborators
  - Francois Roy, CMDN
  - Matteusz Reszka, CMDA
  - Jean-Marc Belanger, RPN-E
  - Frederic Dupont, CMDN
  - Gilles Garric, Mercator-Ocean
  - Jean-Francois Lemieux, RPN-E
  - Christiane Beaudoin, RPN-E
  - Fraser Davidson, DFO
  - Youyu Lu, DFO
  - Greg Smith, RPN-E
  - Mark Buehner, ARMA
  - Alain Caya, ARMA
  - Tom Carrieres, CIS
  - Zhongjie He, RPN-E
  - …



Debris log10 tons – 20110309

Main Deliverables and Timeline

Years 1-3

- Develop relocatable capability of GEM-NEMO system, configured for Strait of Georgia and Scotian Shelf
- Develop Develop relocatable tide and storm surge model to provide boundary conditions for relocatable NEMO

Year 3

- Testing and evaluation at VENUS site in collaboration with IP1.2

Year 4

- Demonstrate relocatable system on Scotia Shelf (with OTN and Observation Core, including small scale tracer release experiment)
- Complete testing and real-time implementation in Strait of Georgia