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

Harold Ritchie and many colleagues
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Canada

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Environment Canada　Environnement Canada

Canada

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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 (Argo, altimetry,...) in order to
  - produce new ocean products
  - improve weather and climate predictions
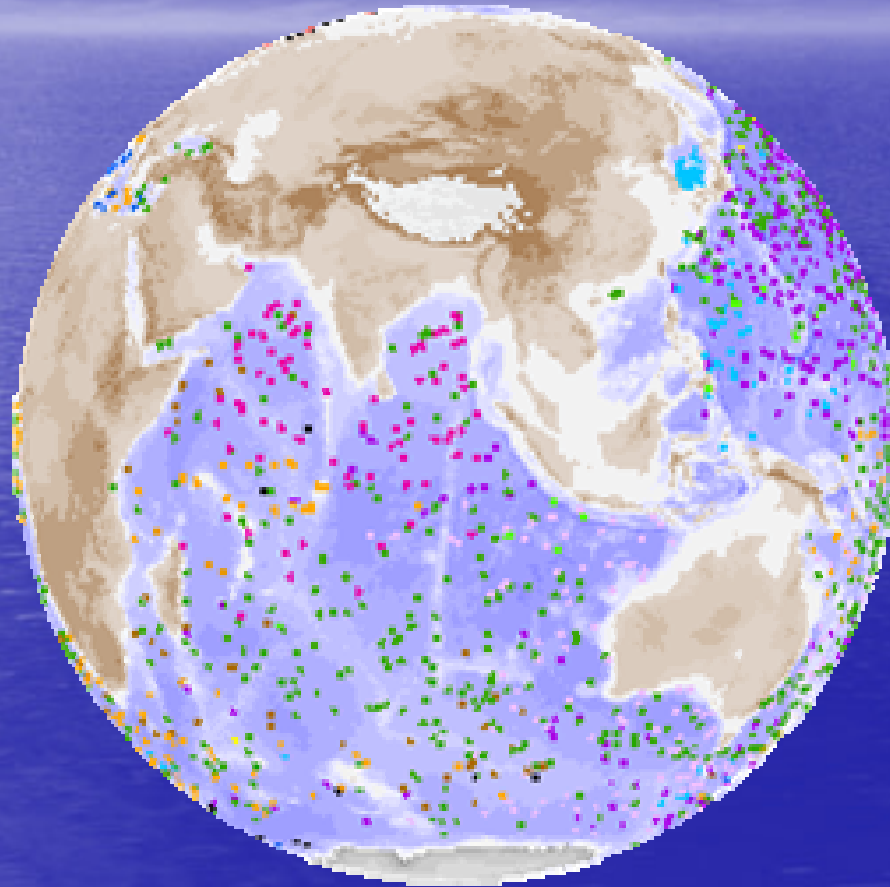
The Global Armada of Argo Floats

Image courtesy of Howard Freeland

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.
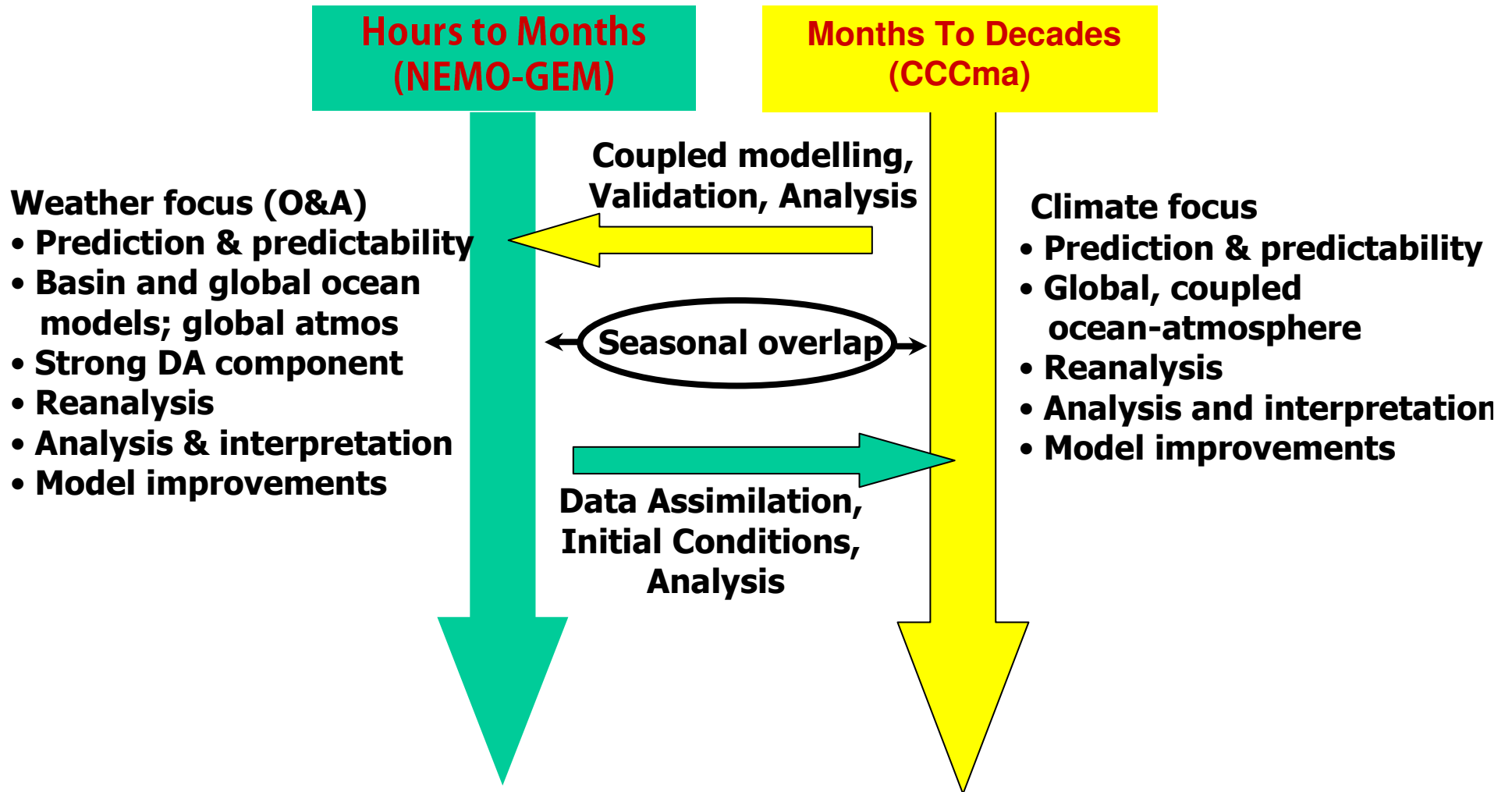
Partnerships

- For cost effectiveness, EC, DFO and DND are collaborating on this major initiative.

- We have initiated the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS)

- Partnering with Mercator-Ocean (France) for ocean aspects (Nucleus for European Modelling of the Ocean (NEMO) system)

Status Report

- EC-DFO-DND Memorandum of Understanding ready for Canadian inter-agency collaboration
- Canada-Mercator agreement drafted for international partnership
- 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 17 PIs for 4 years), started October 2006

Global Ocean-Atmosphere Prediction and Predictability (GOAPP) Network

Hours to Months (NEMO-GEM)

Months To Decades (CCCma)

Coupled modelling, Validation, Analysis

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

Seasonal overlap

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

Data Assimilation, Initial Conditions, Analysis

CONCEPTS Three-Track Approach

- <u>Initial resources</u> are in place to establish:
- <u>Operational activity</u>: built on existing EC infrastructure by coupling the Canadian atmospheric GEM model with the Mercator NEMO system
- <u>Research and development activity</u>: consisting of long-term government research and complementary academic research networks
- <u>Products activity</u>: to identify, develop and disseminate relevant products & outputs

Progress in key 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

Global NEMO Configurations
Global ocean tri-polar grids

ORCA1: nominal 1° in lat/long; ~23 km grid spacing in CAA
ORCA025: nominal 1/4° in lat/long; ~6 km grid spacing in CAA
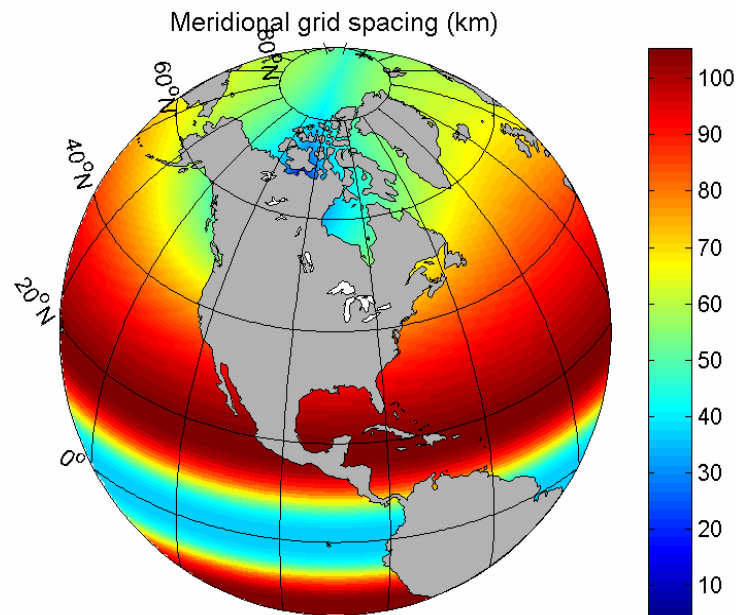
ORCA1
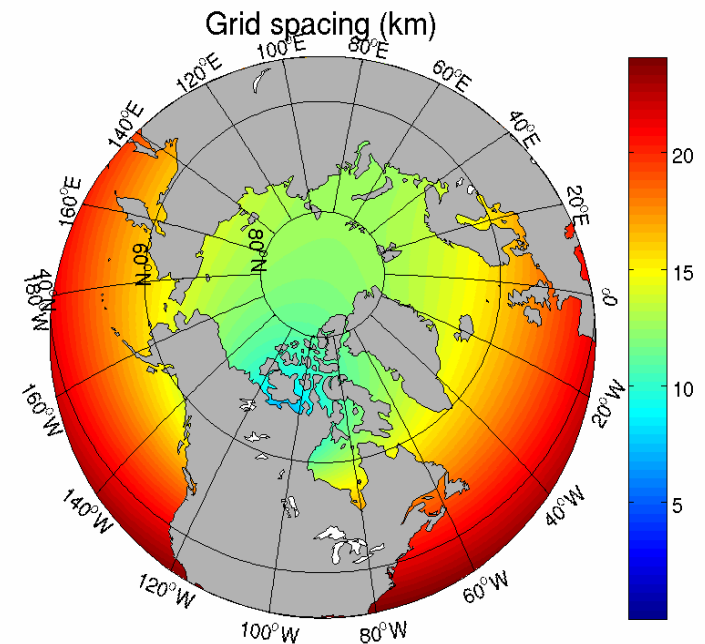
ORCA025

Snapshot of Sub-surface flow
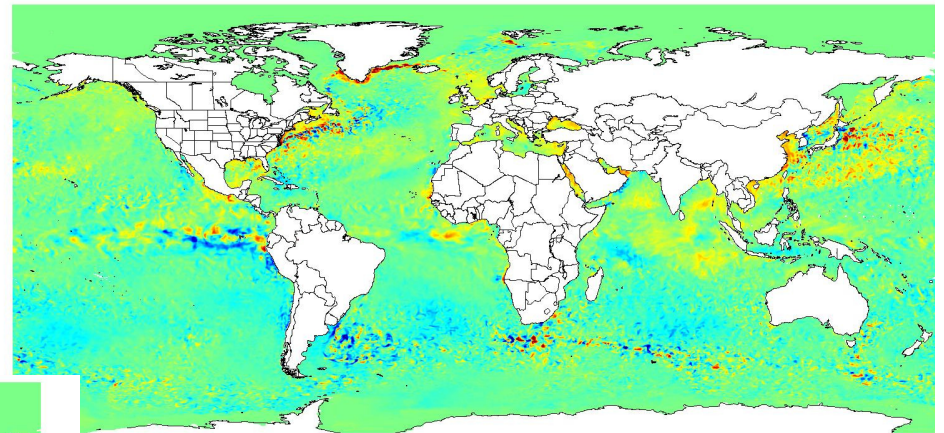

Velocity at 10 m, Dec 31, Year 6
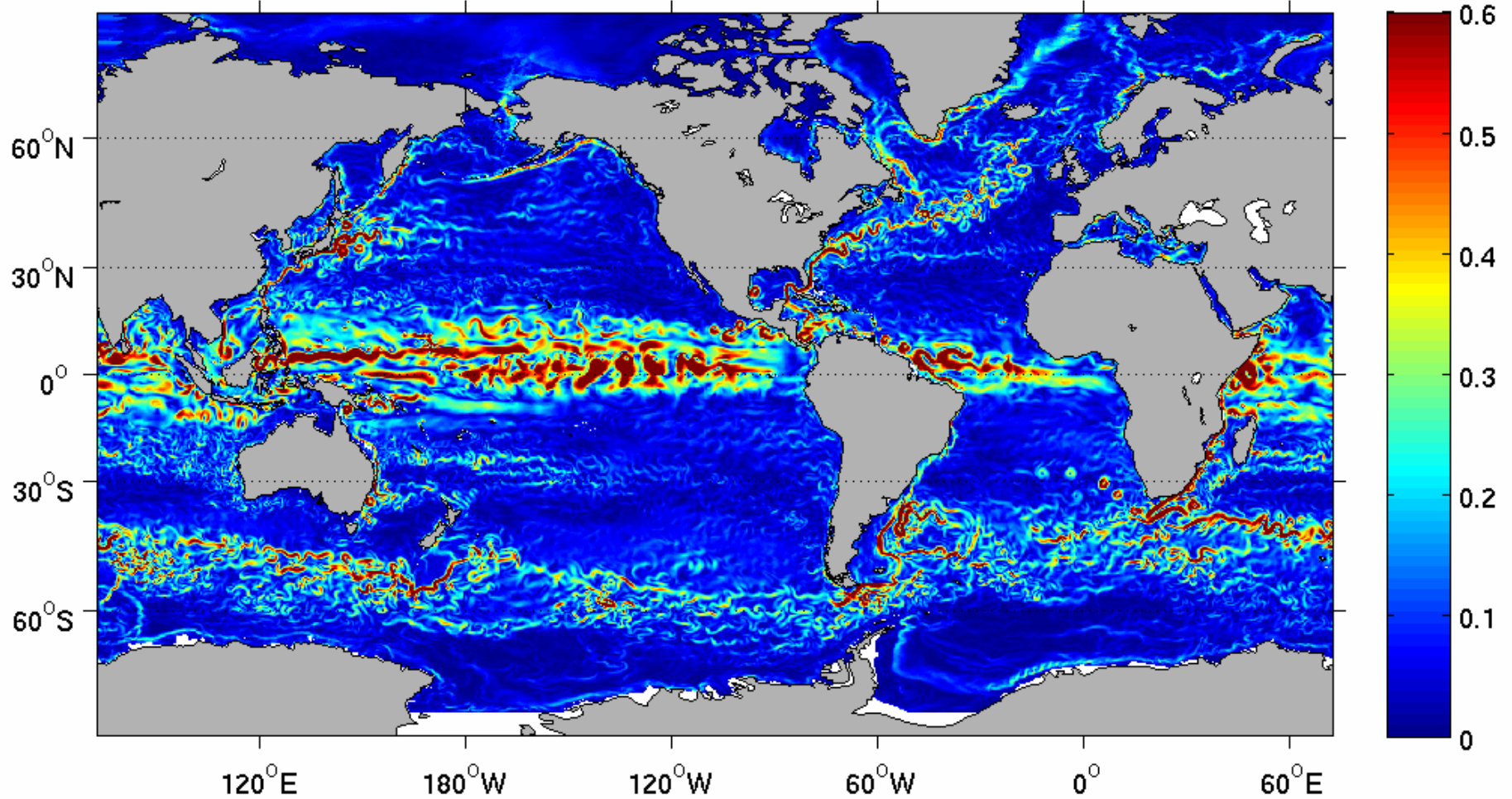
Initial Ocean Forecast Assessment

SST trend over a 10-day cycle (April 19-28, 2007)
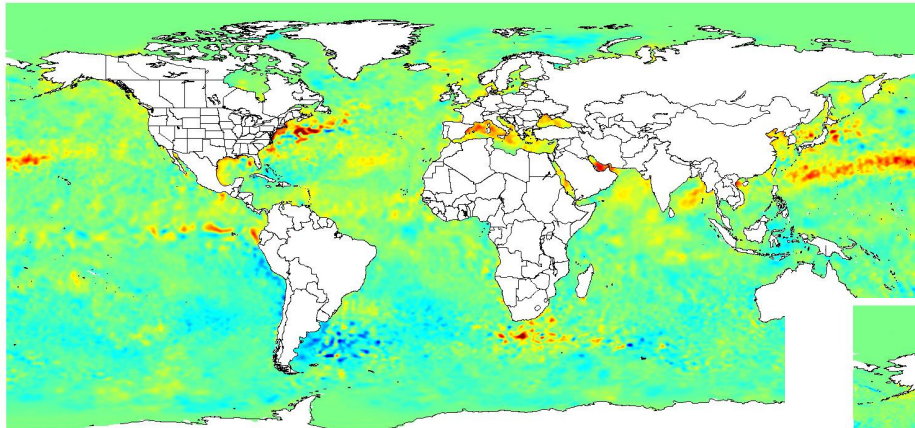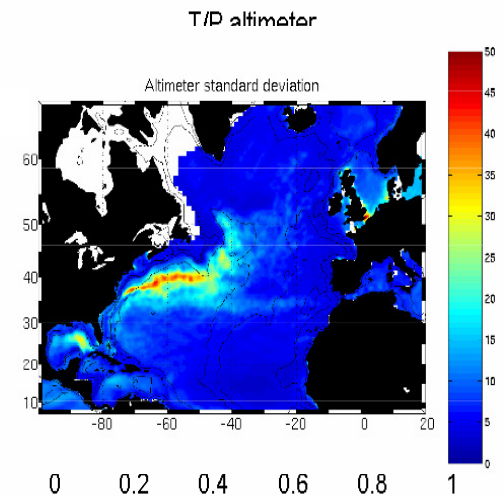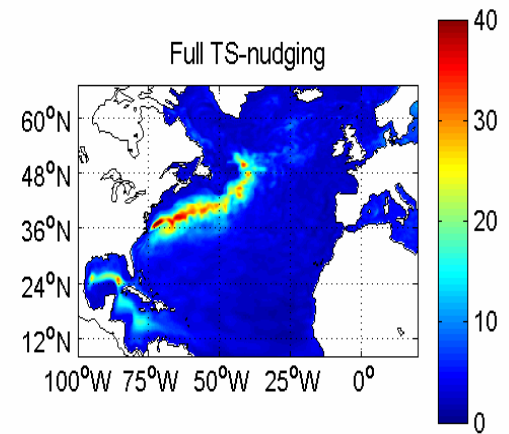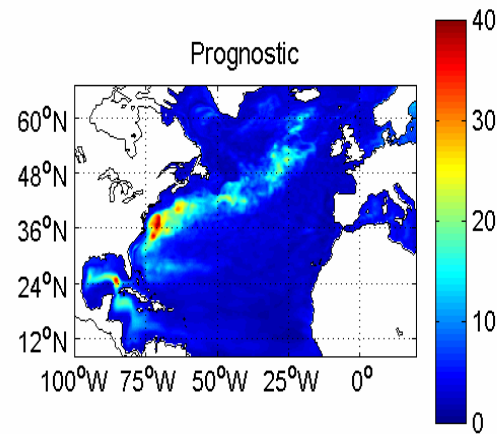

CMC analysis based on observations

**Forecast with ECMWF forcing**
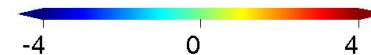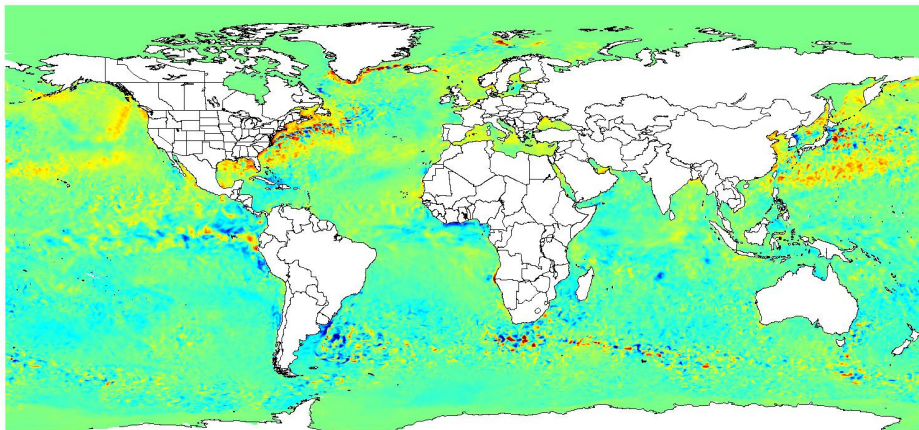
Forecast with GEM forcing

Spectral Nudging

Prognostic

Full TS-nudging

T/P altimeter

Altimeter standard deviation

- Implemented and tested in ¼º NA model
- Results comparable to POP experience

- Encouraging results with 1º global model

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NEMO at Royal Military College (Stacey)

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

Temperature, month=11
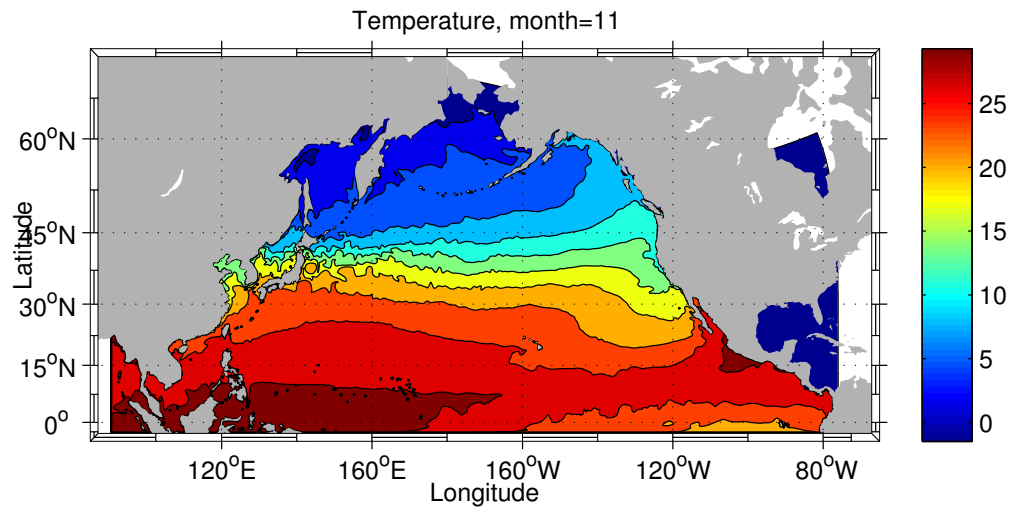
C-NOOFS Update for MERCATOR – Canada Activities

To provide daily 3D state of the ocean now-cast and forecast bulletins for the Eastern Canadian Shelves
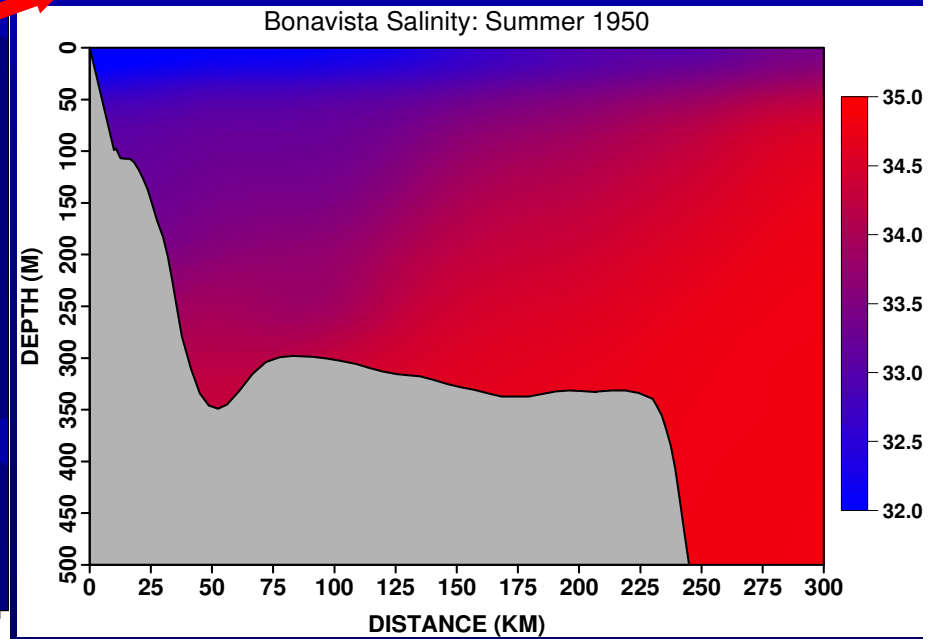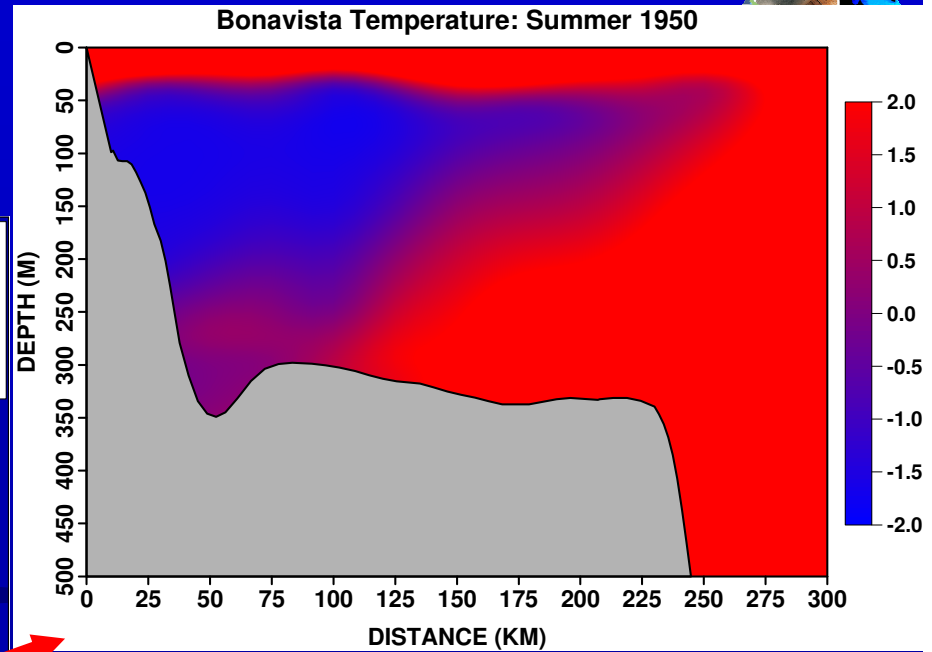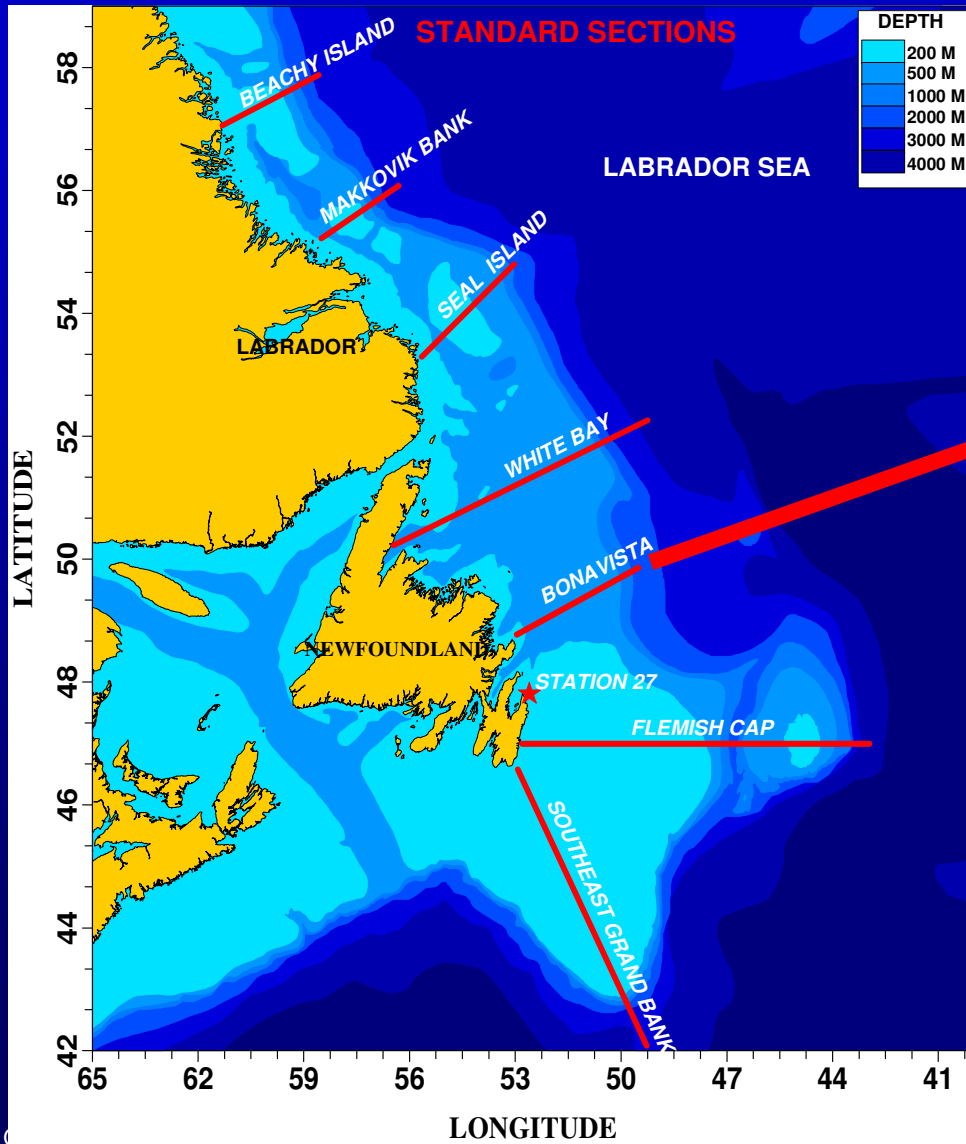
Developing expertise in Operational Oceanography

Output

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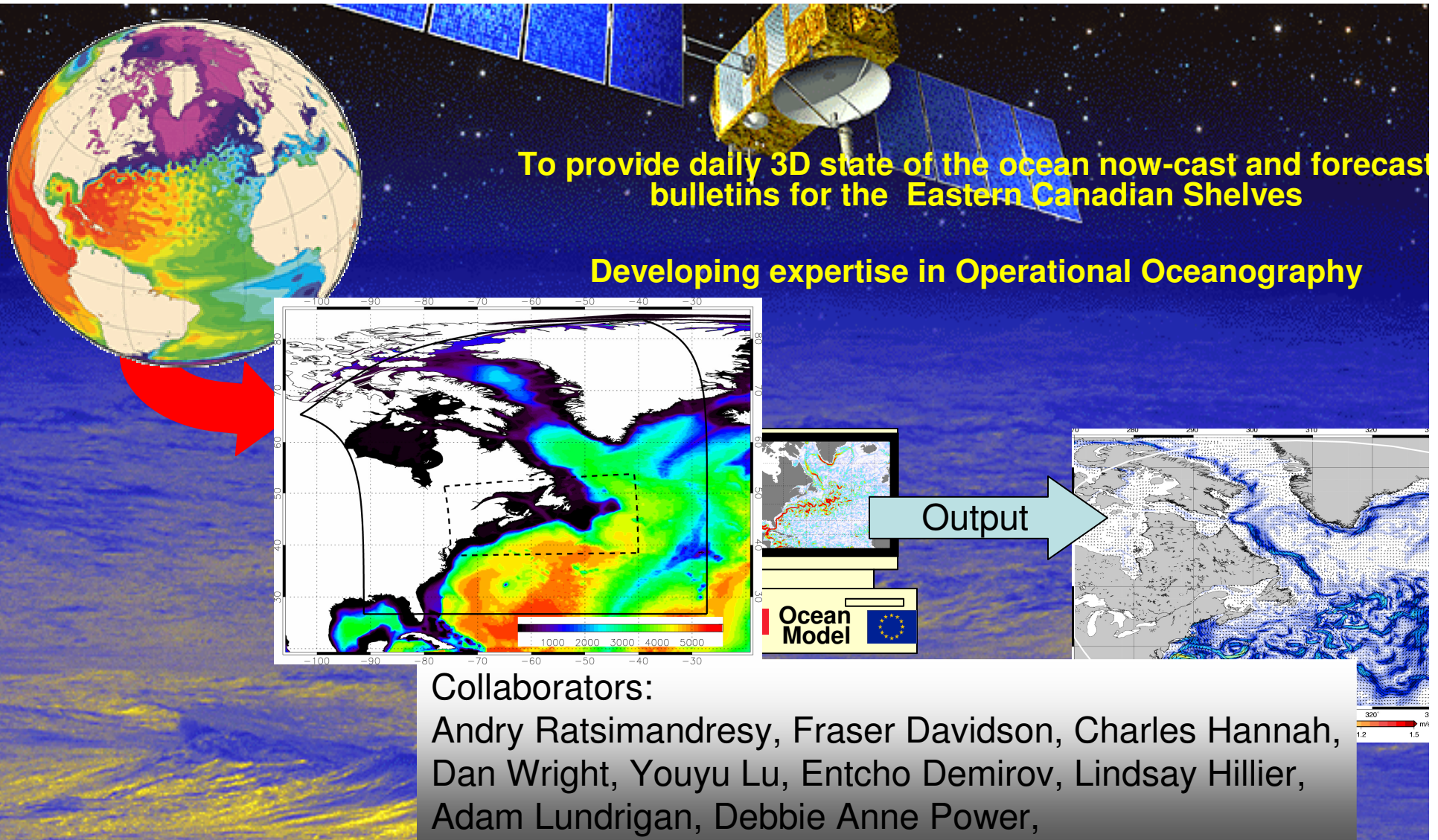
Collaborators:
Andry Ratsimandresy, Fraser Davidson, Charles Hannah, Dan Wright, Youyu Lu, Entcho Demirov, Lindsay Hillier, Adam Lundrigan, Debbie Anne Power,

LONG TERM OCEAN CLIMATE MONITORING SECTIONS

STANDARD SECTIONS

BEACHY ISLAND

MAKKOVIK BANK

SEAL ISLAND

LABRADOR

WHITE BAY

BONAVISTA

NEWFOUNDLAND

STATION 27

FLEMISH CAP

SOUTHEAST GRAND BANK

LABRADOR SEA

DEPTH
200 M
500 M
1000 M
2000 M
3000 M
4000 M

LATITUDE

LONGITUDE

Bonavista Temperature: Summer 1950

DEPTH (M)

DISTANCE (KM)

Bonavista Salinity: Summer 1950

DEPTH (M)

DISTANCE (KM)

Sea-Ice Data Assimilation Project

- ▮: to develop an automated ice analysis system for:

  - ▮ Ice Service (CIS): ice concentration, thickness/type distribution, ▮ strength and edge, deformed ice at ~1-2 km resolution

  - ▮ concentration, thickness, albedo, surface emissivity at ~5 km

- ▮ between CIS and Meteorological Research

- ▮ experience with variational and ensemble-based ▮ for NWP:

  - ▮ional approach: incremental 3D-FGAT (first guess at appropriate

- ▮itial prototype analysis system using CIS ice-ocean model ▮ east-coast → plan to port system to other models/regions:

  - ▮ Arctic archipelago region (IPY project, Polar-GEM)

  - ▮ Lawrence (coupled ice-ocean-atmosphere model developed at

Canada

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
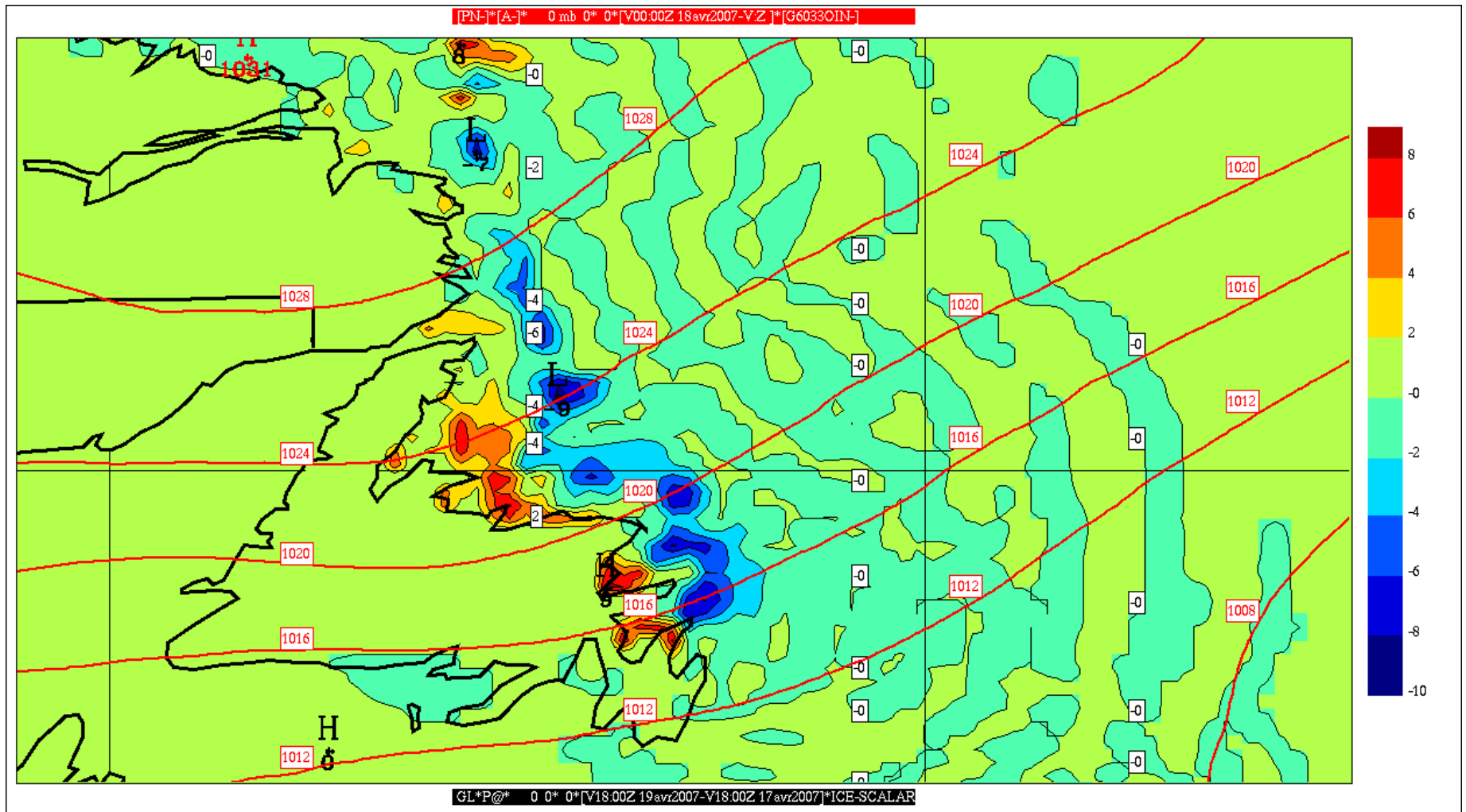
Short Term Predictability of the North Atlantic

Goals: 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.**

Forecast Skill For Sea Level
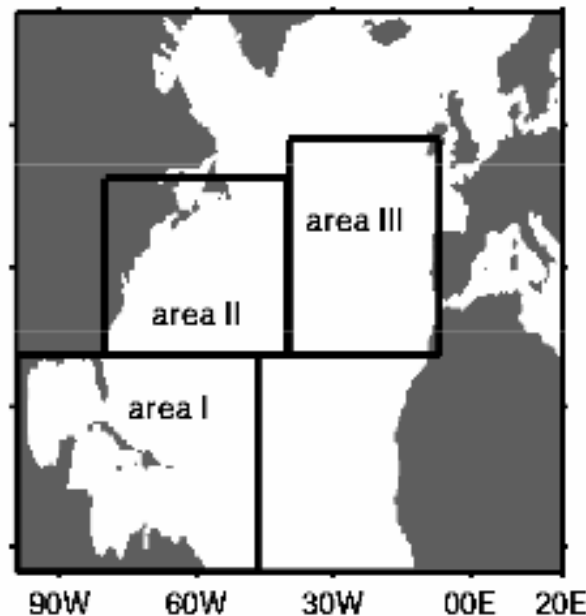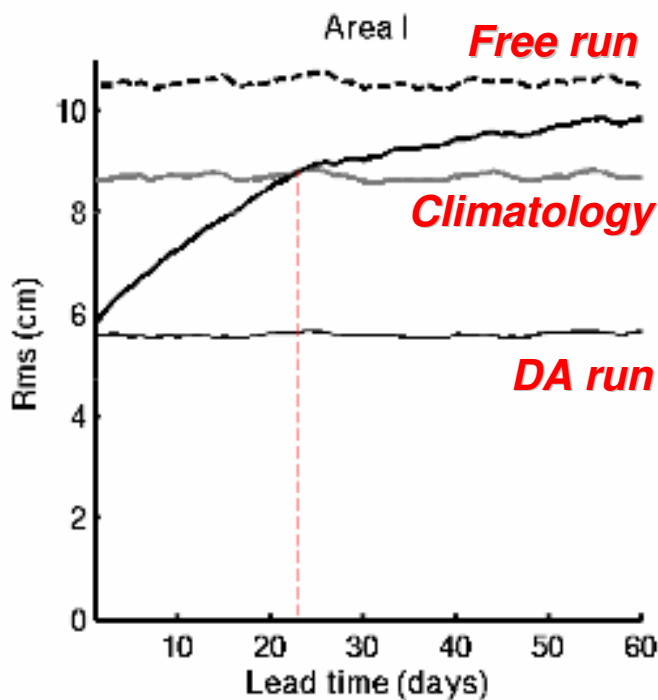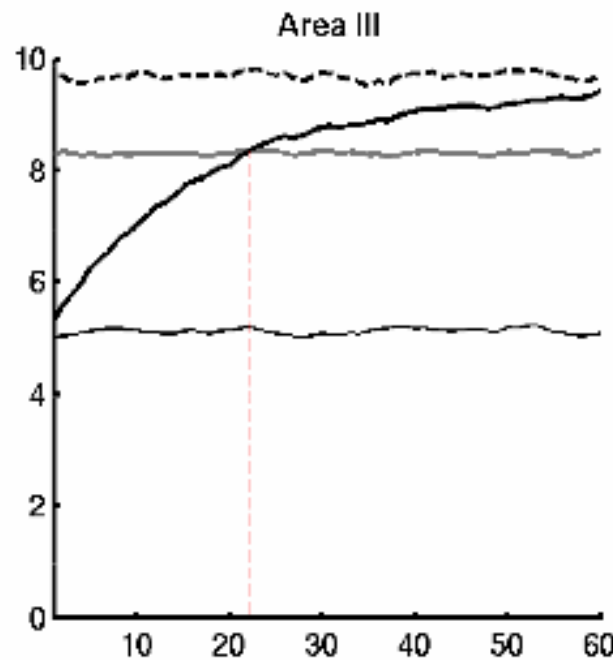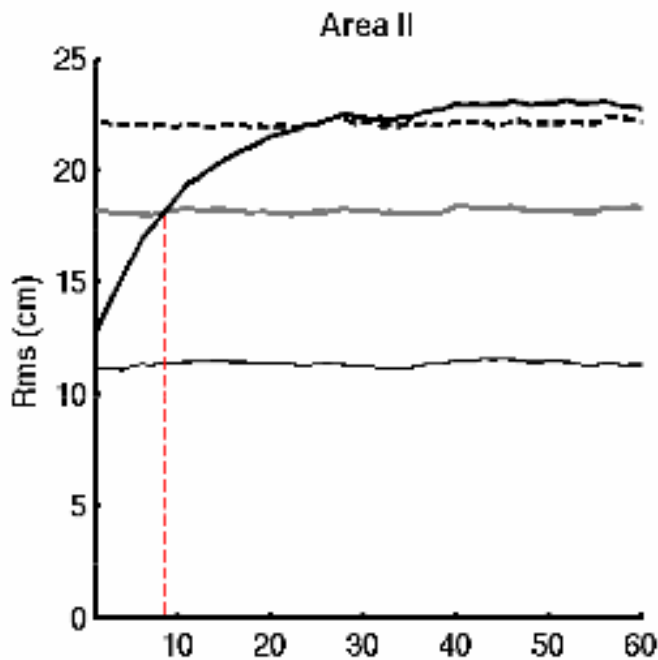
- **Rms of obs-pred vs lead time**

- **Based on 24 monthly forecast runs (each 60d)**

Summary

- Development of an operational Canadian global assimilation and prediction capability for the coupled atmosphere-ocean-ice system has begun.
- There are strong interactions with the complementary Global Ocean-Atmosphere Prediction and Predictability (GOAPP) research network funded by CFCAS.
- Collaborative research projects are in progress.
- Required long-term resources are being sought.

Thank you!