Dynamic Downscaling of Ocean Circulation over the Eastern Canadian Shelf using NEMO

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GOAPP
Global Ocean-Atmosphere Prediction and Predictability

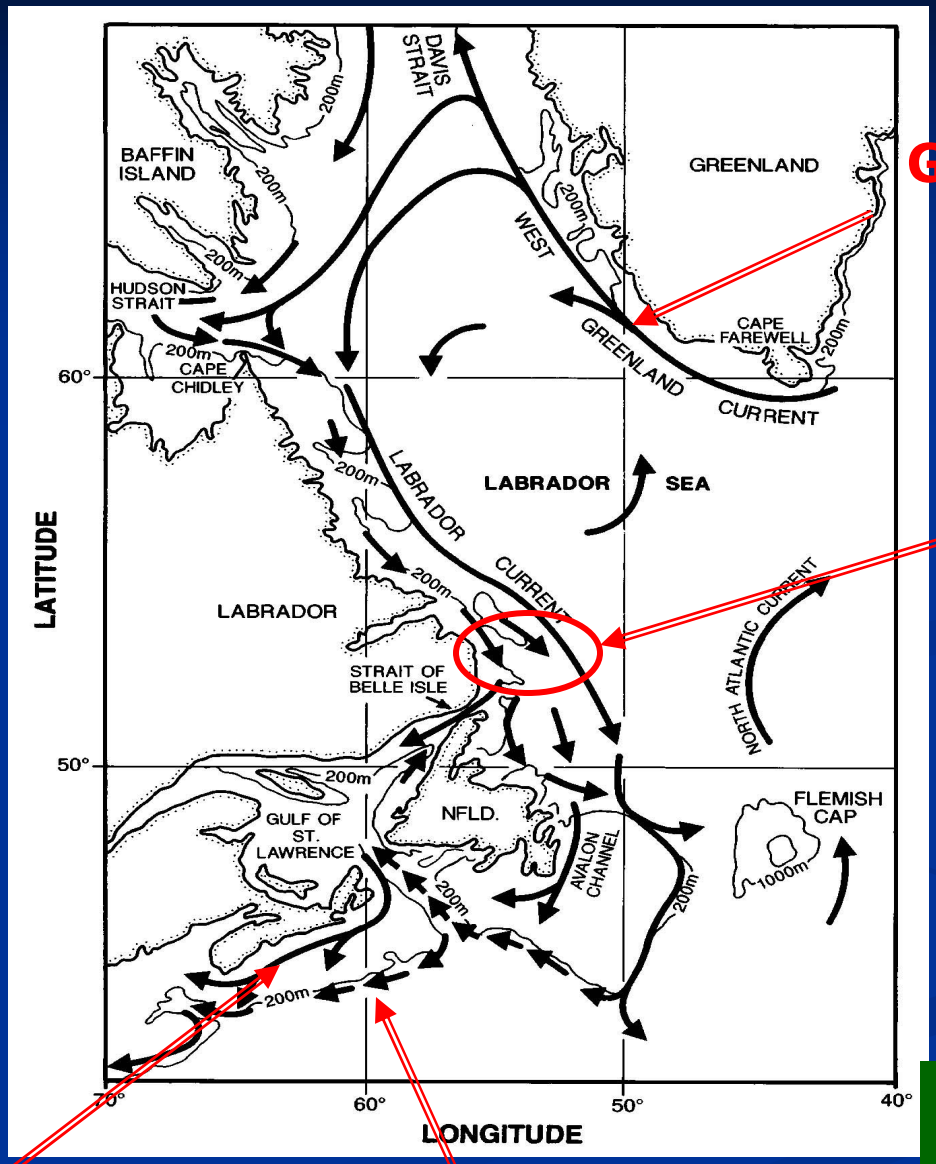
Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)
Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA)

Outline

1. Introduction
2. Development of a dynamically downscaling shelf circulation model for the eastern Canadian Shelf using NEMO
3. Preliminary model results
4. Summary

Jorge Urrego-Blanco will present a numerical study of interannaul variability of circulation over the eastern Canadian shelf using this regional ocean circulation model (ID 7, 14:30 Tuesday).

Introduction



Greenland Current

Labrador Current

Scotian Shelf Current

NS Shelf-Break Jet

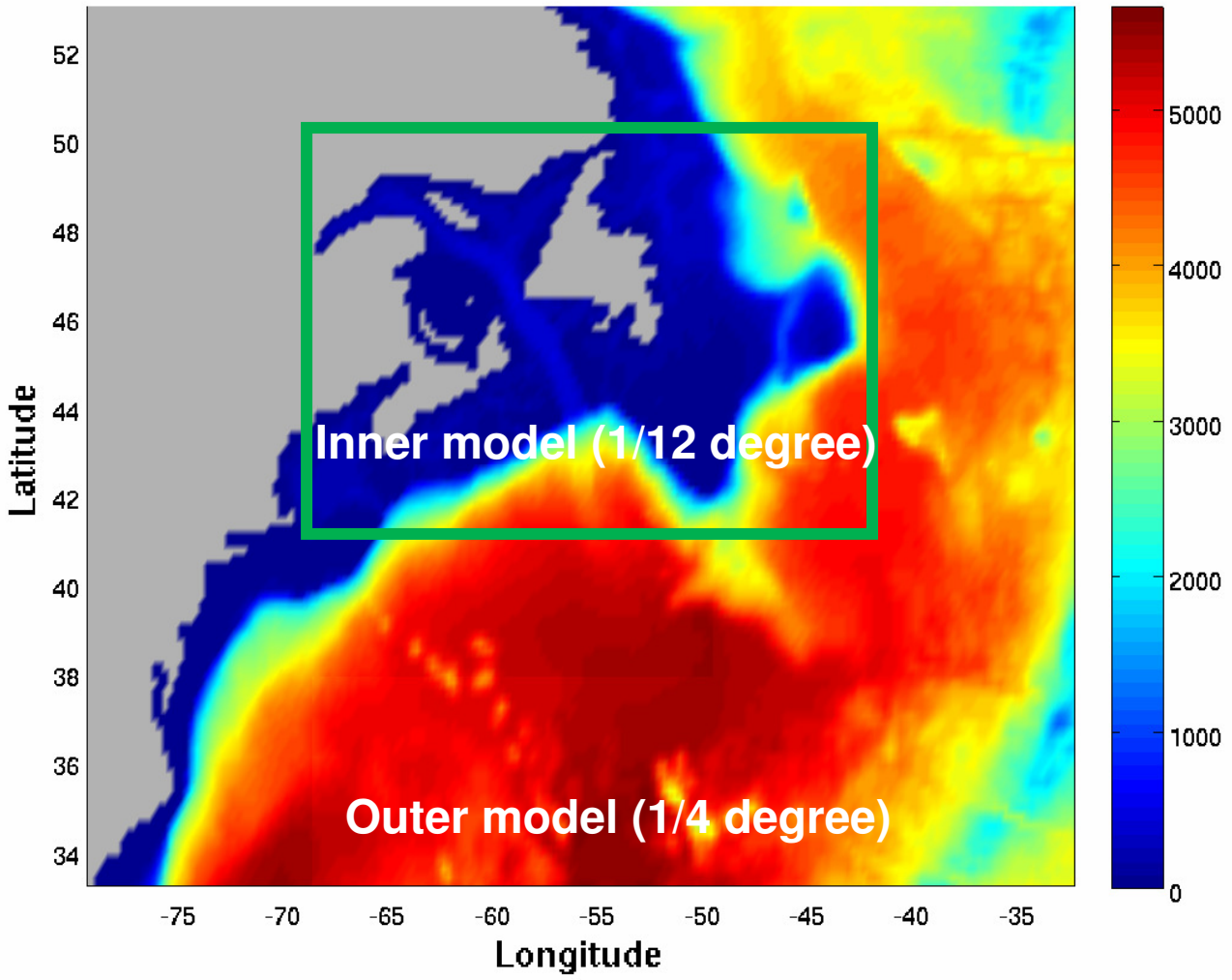
(Colbourne et al., CJFAS, 1997)

Main objectives:

- To develop a nested-grid shelf circulation model for the eastern Canadian shelf using NEMO.

- To examine predictability of the regional shelf circulation model in predicting circulation and water mass distributions on the eastern Canadian shelf on time scales of days to months.

A nested-grid ocean circulation model for the eastern Canadian Shelf



- The nested-grid shelf circulation model for the eastern Canadian shelf will have two components: a coarse-resolution (1/4^{o}) outer model covering the northwest Atlantic Ocean and a fine-resolution (1/12^{o}) inner model covering the Newfoundland Shelf, Gulf of St. Lawrence and Scotian shelf.
- Great efforts have been made in developing and calibrating the outer model.
- This talk will focus on the development of the outer model.
- Jorge Urrego-Blanco will discuss the application of the outer model in simulating interannaul variability of circulation over the eastern Canadian shelf (ID 7, 14:30 Tuesday)

Main features of the outer model

- Based on NEMO-OPA using a horizontal resolution of $(1/4)^o$ and 46 z-levels with partial cells in the vertical.
- Using the combination of the spectral nudging method (Thompson et al., and semi-prognostic method (Sheng et al., 2001) with much weaker nudging coefficients
- Forced by 6-hourly surface wind stress (NCAR/NCEP reanalysis data) and interannually varying monthly mean surface heat and freshwater flux (Large and Yeager, 2009).
- Open boundary conditions are based on 5-day averaged reanalysis data produced by the British Atmospheric Data Centre (BADC, RAPID project).
- Using monthly mean climatology of temperature and salinity of Geshelin et al. (1999) in the Spectral-nudging and semi-prognostic methods.

The Spectral Nudging Method

The key of this method is to add a correction term to the tracer equation (Thomson et al., 2009):

$$\frac{\partial T}{\partial t} = -\vec{u} \cdot \nabla T + \nabla \cdot A \nabla T + \left\langle \frac{T_c - T_m}{\tau} \right\rangle$$

The spectral nudging method is implemented in the model code using

$$T_{n+1} = T_{n+1} + \gamma S \left\langle T^c_{n+1} - T^f_{n+1} - \phi(T^c_{n-1}, T^c_n, u_c) + \phi(T_{n-1}, T_n, u_c) \right\rangle$$

Three important parameters: γ, S, and κ.

In this study we use $\gamma = \Delta t/\tau$, τ=200 days, κ^{-1}=3 yrs, S is a horizontal smoothing operator using 3x3 matrix (5 iterations).

The Semi-Prognostic Method

• The main idea of the method is to add a pressure correction term to the model momentum equation (Sheng et al., 2001):

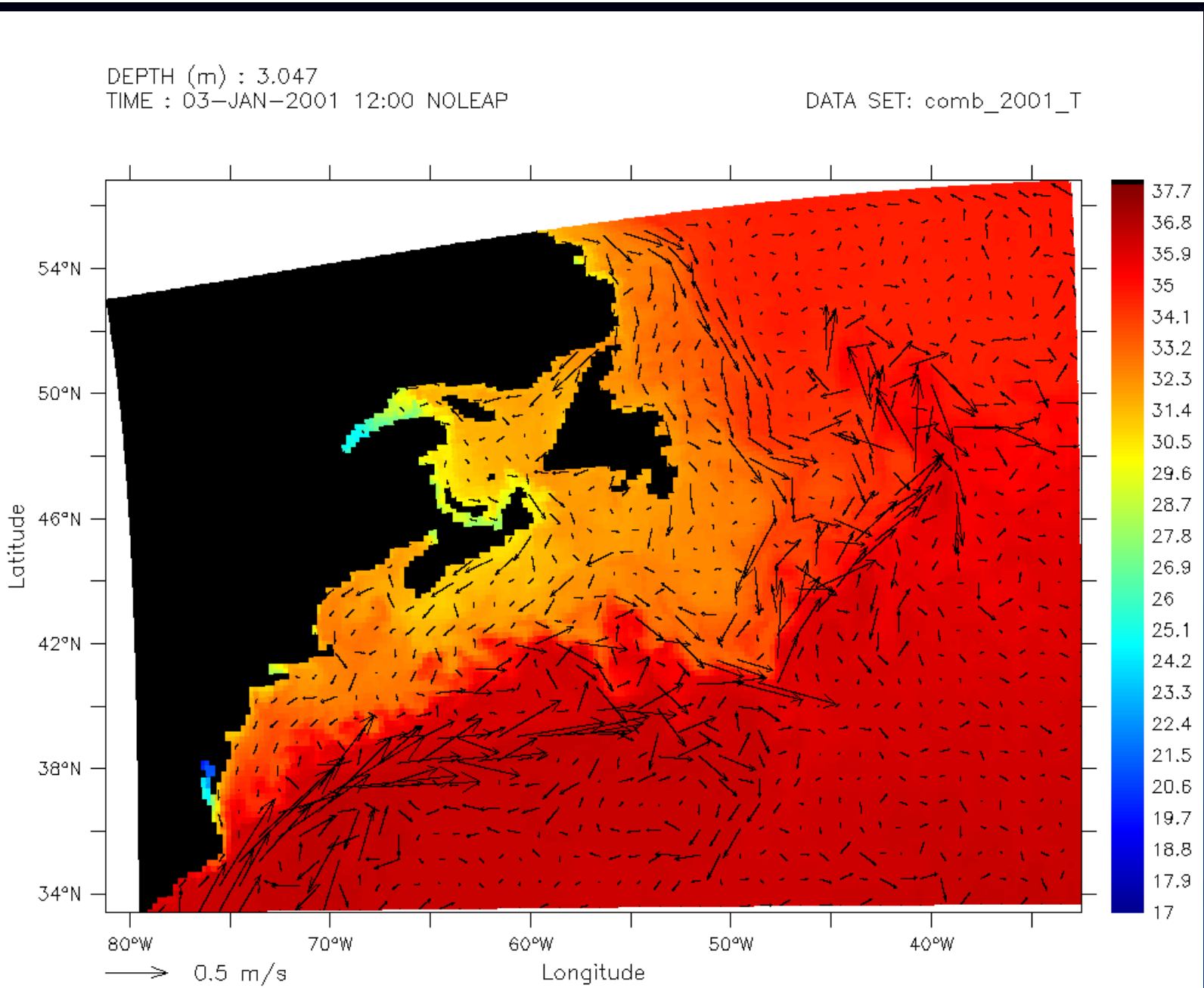
$$\frac{\partial u}{\partial t} = -\frac{1}{\rho_o}\frac{\partial p_c}{\partial x} - \frac{1}{\rho_o}\frac{\partial \tilde{p}}{\partial x} + \cdots\cdots$$

• The pressure correction term is calculated by (β=0.25)

$$\frac{\partial p}{\partial z} = \frac{\partial (p + \tilde{p})}{\partial z} = -\left(\rho_m + \beta\langle \rho_c - \rho_m \rangle\right) g$$

• The model temperature and salinity evolve freely with the model currents:

$$\frac{\partial T}{\partial t} = -\nabla \bullet (\vec{u} T) - \nabla \bullet (A \nabla T)$$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TIME : 03-JAN-2001 12:00 NOLEAP
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50°N
46°N
42°N
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80°W
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60°W
50°W
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Longitude
0.5 m/s
37.7
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35.9
35
34.1
33.2
32.3
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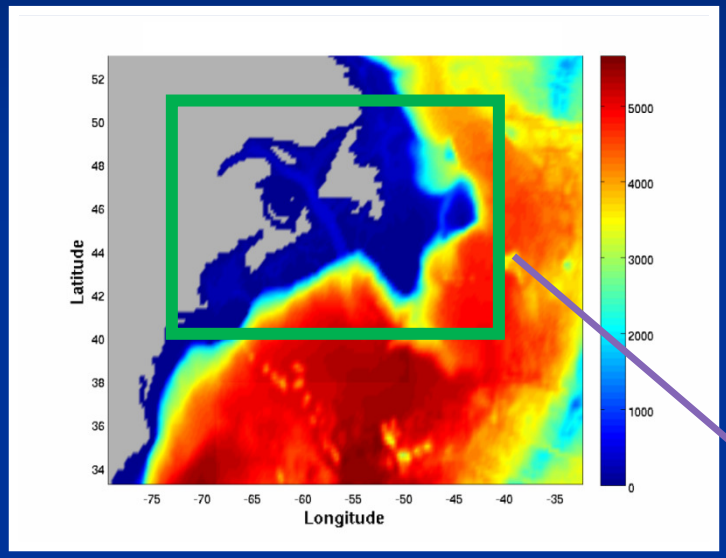
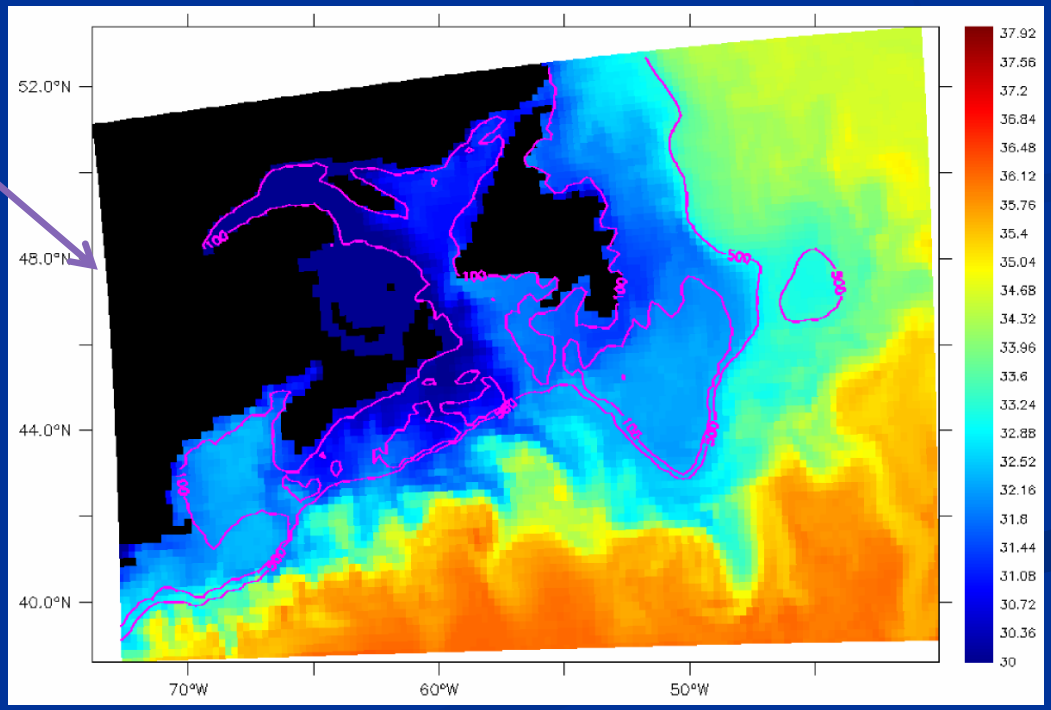
28.7
27.8
26.9
26
25.1
24.2
23.3
22.4
21.5
20.6
19.7
18.8
17.9
17
Salinity (PSU)

Ocean Circulation over the Eastern Canadian Shelf using MEMO (1995-2004)

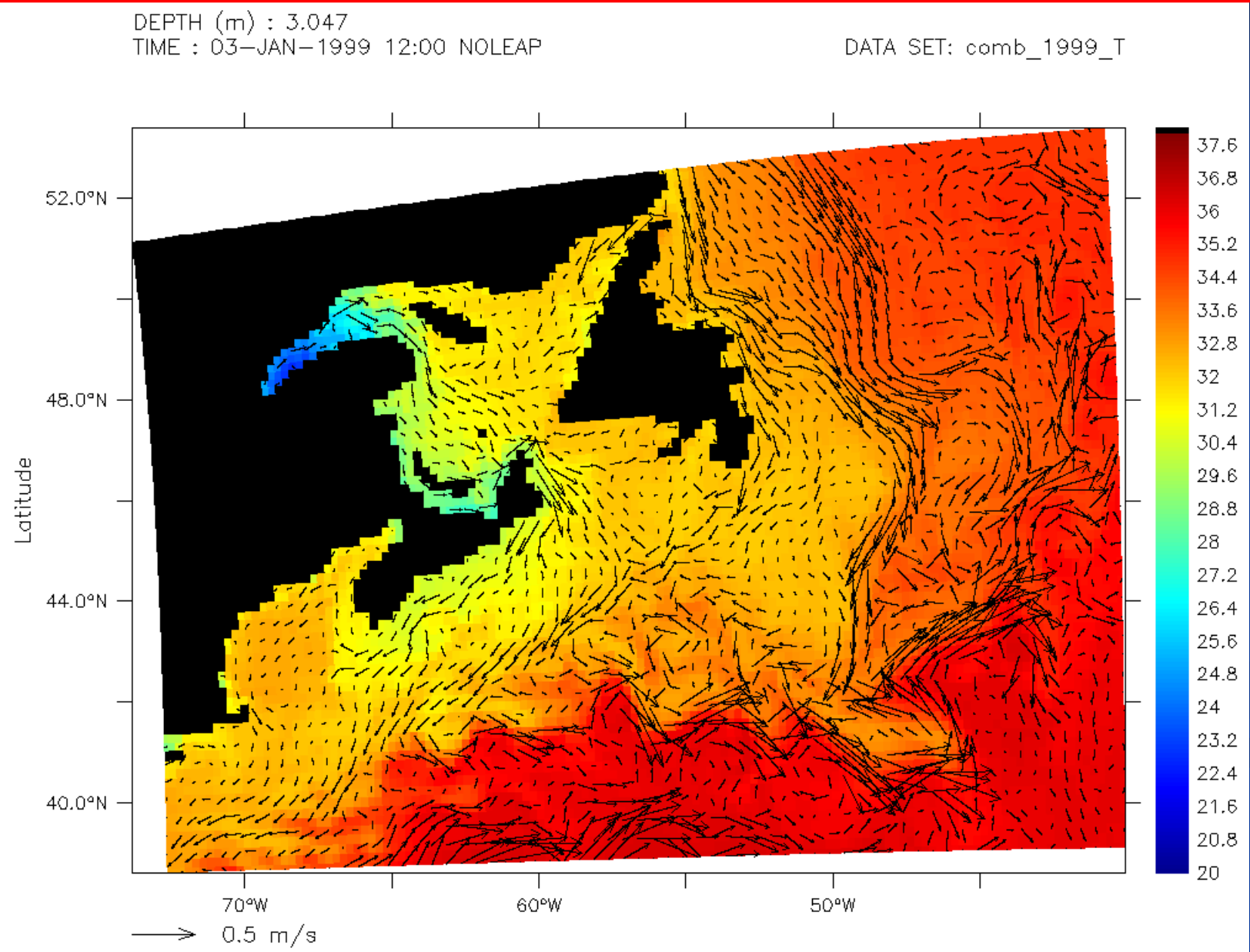


Model Domain and Topography

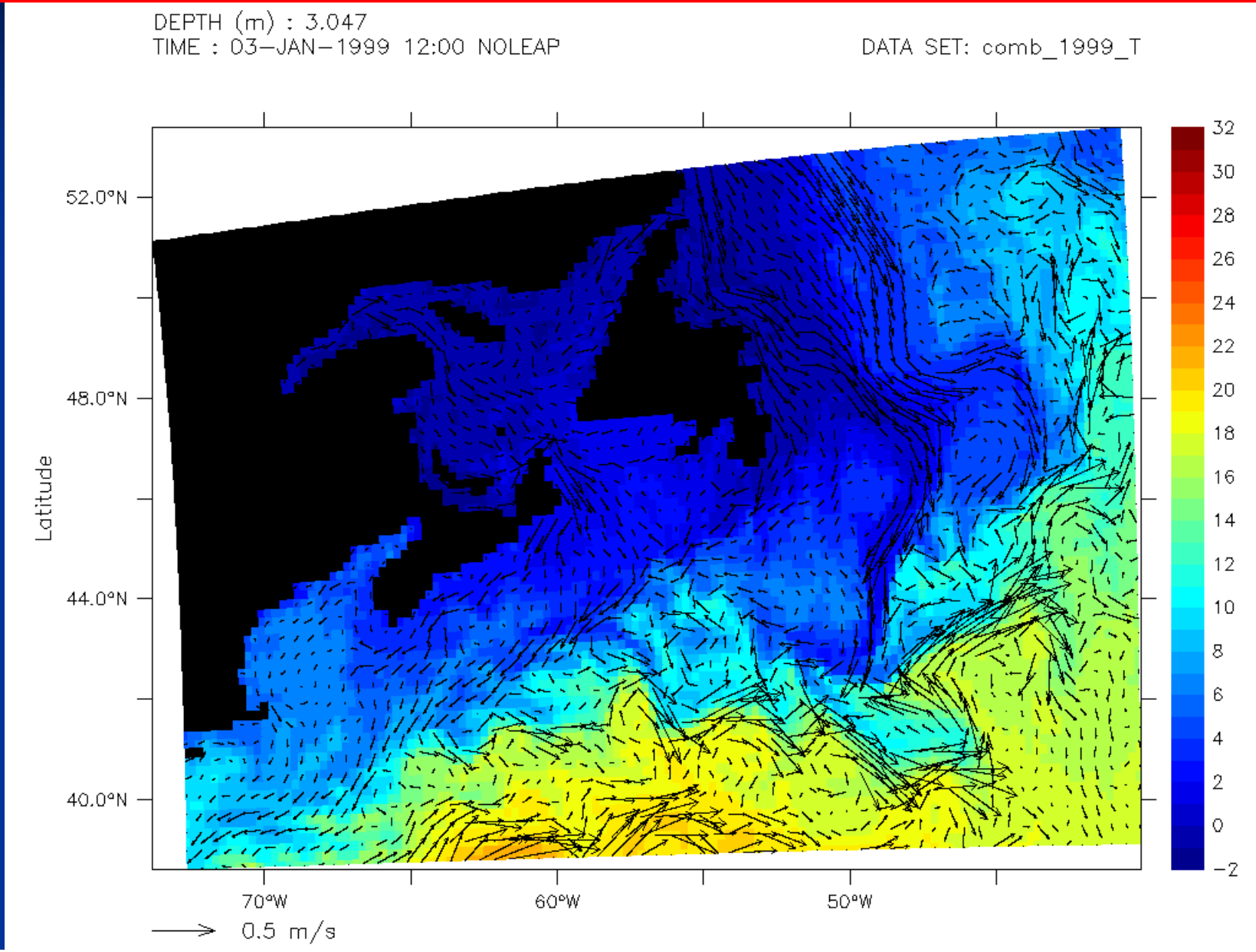


Simulated Sea Surface Salinity (12:00 20-Oct-2001)

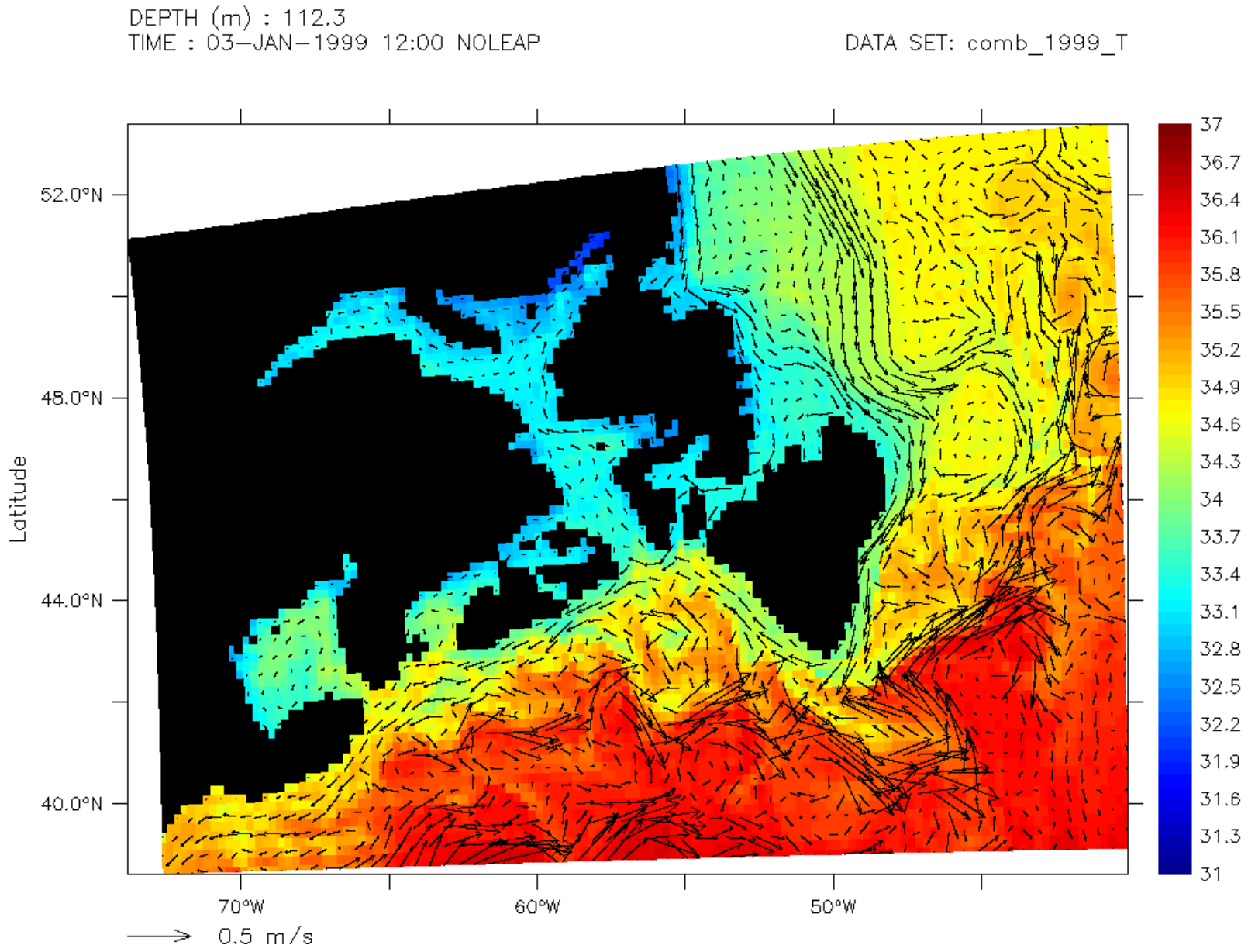
Near-surface (3 m) salinity and currents produced by the outer model (1999-2001)



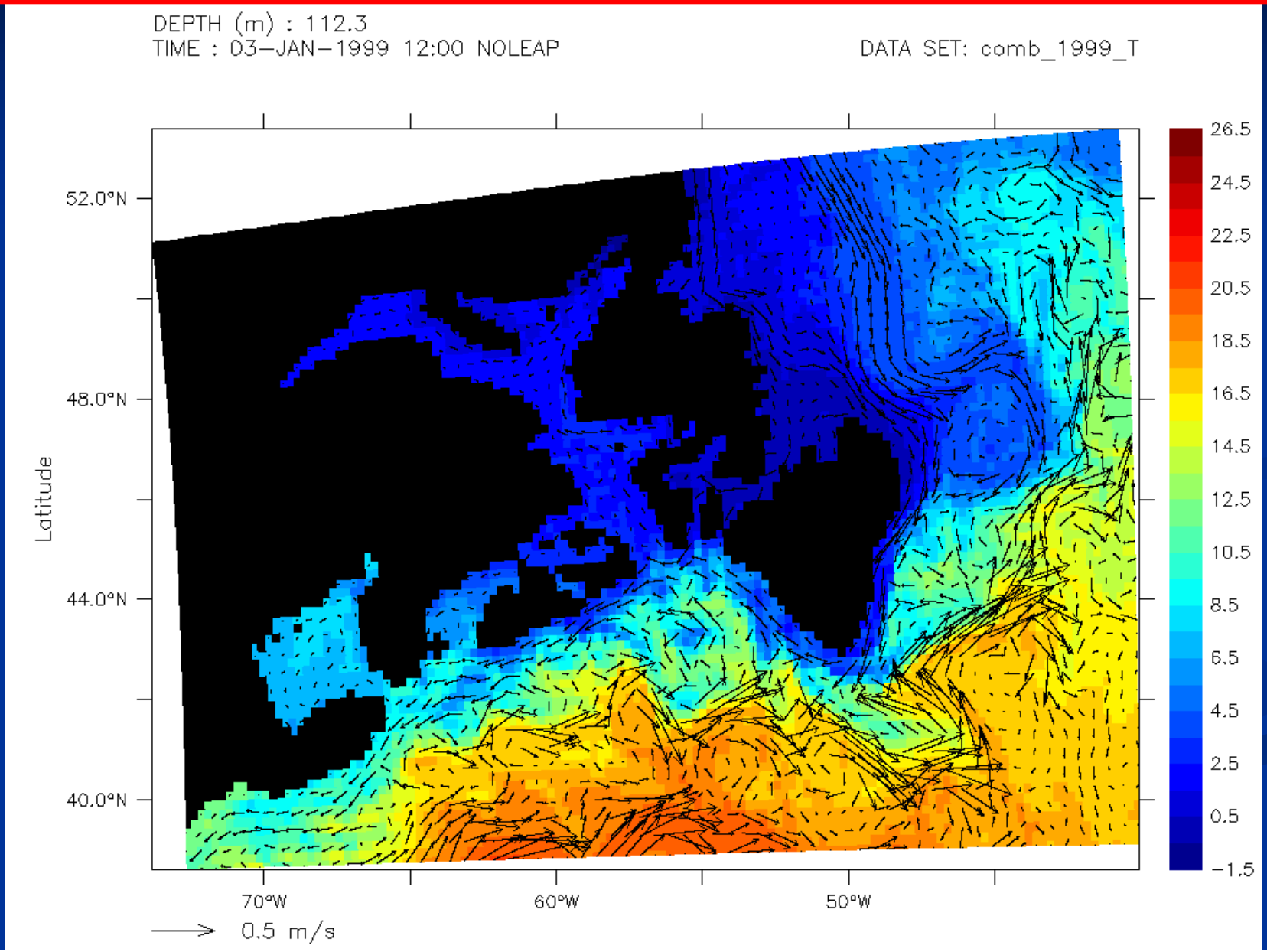
Near-surface (3 m) temperature and currents produced by the outer model (1999-2001)



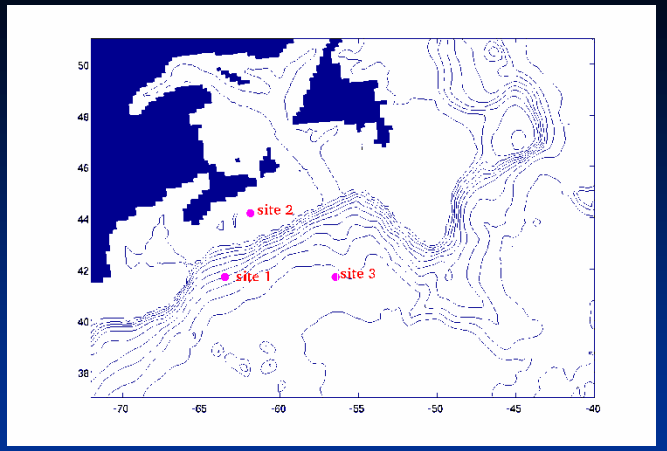
Sub-surface (112 m) salinity and currents produced by the outer model (1999-2001)

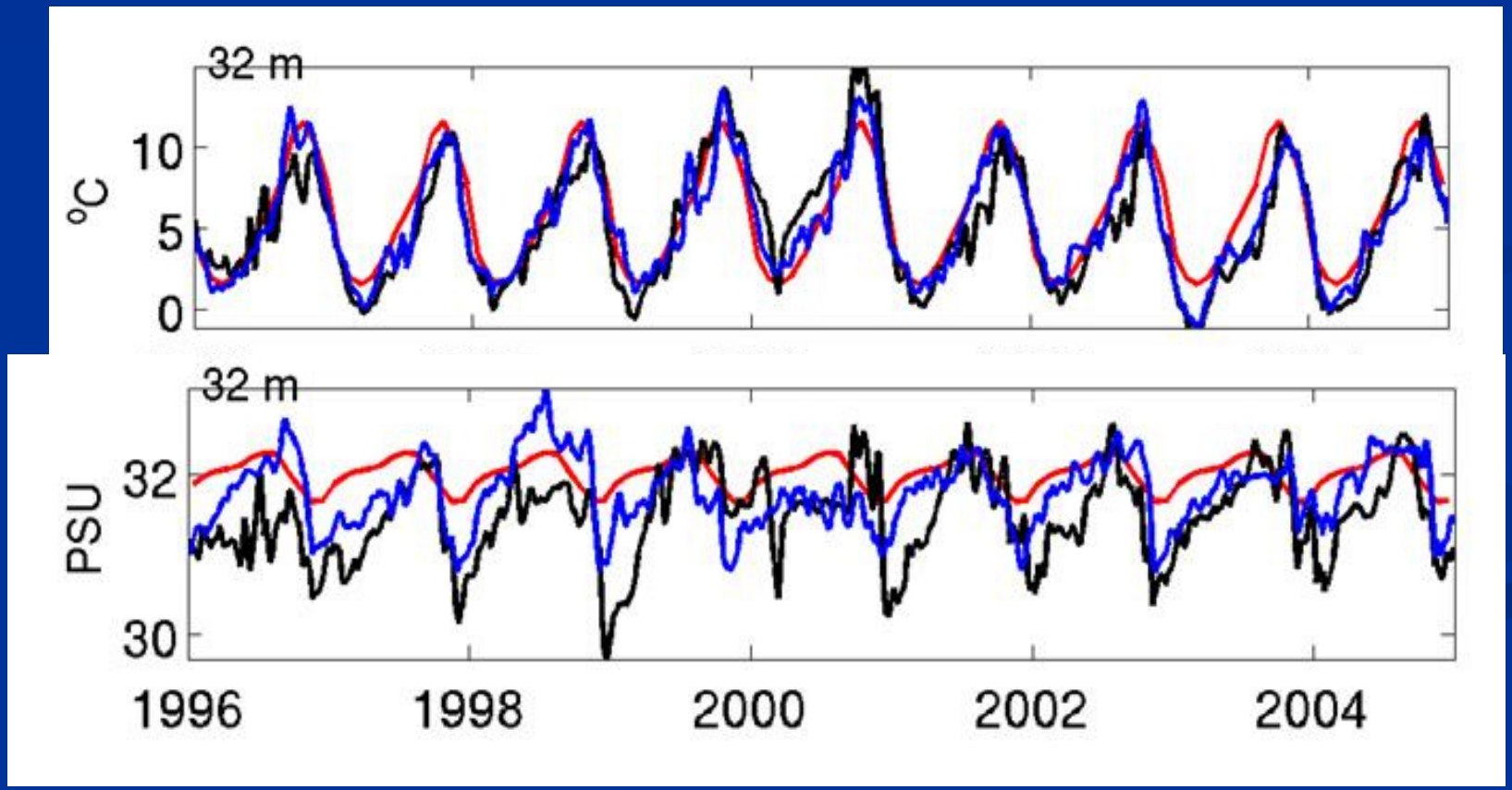


Sub-surface (112 m) temperature and currents produced by the outer model (1999-2001)

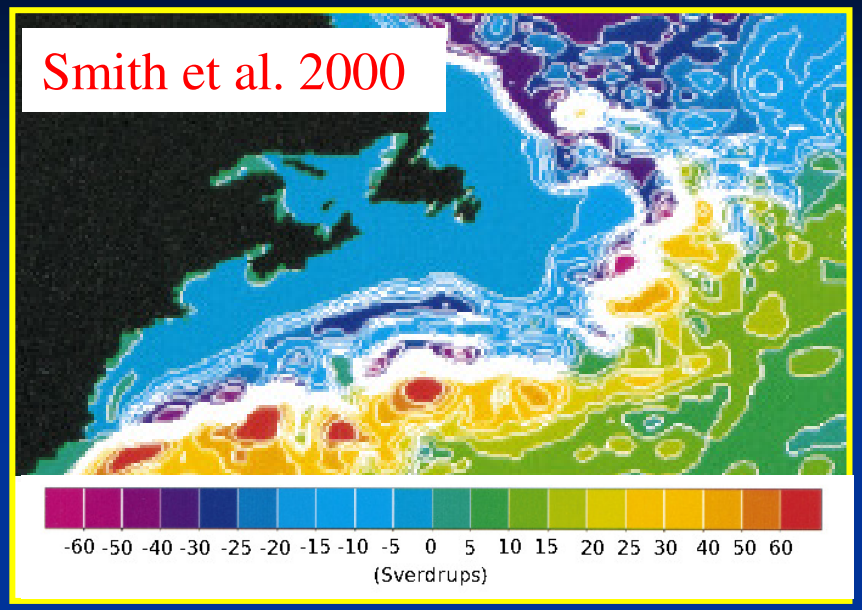


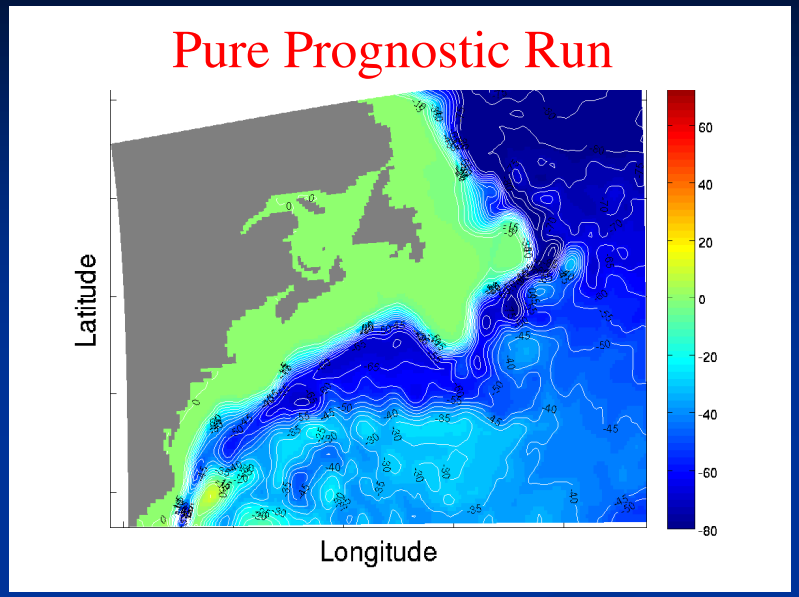
Climatological monthly mean TS (red) and model results at site 2 in the control run (blue) and pure prognostic run (black)

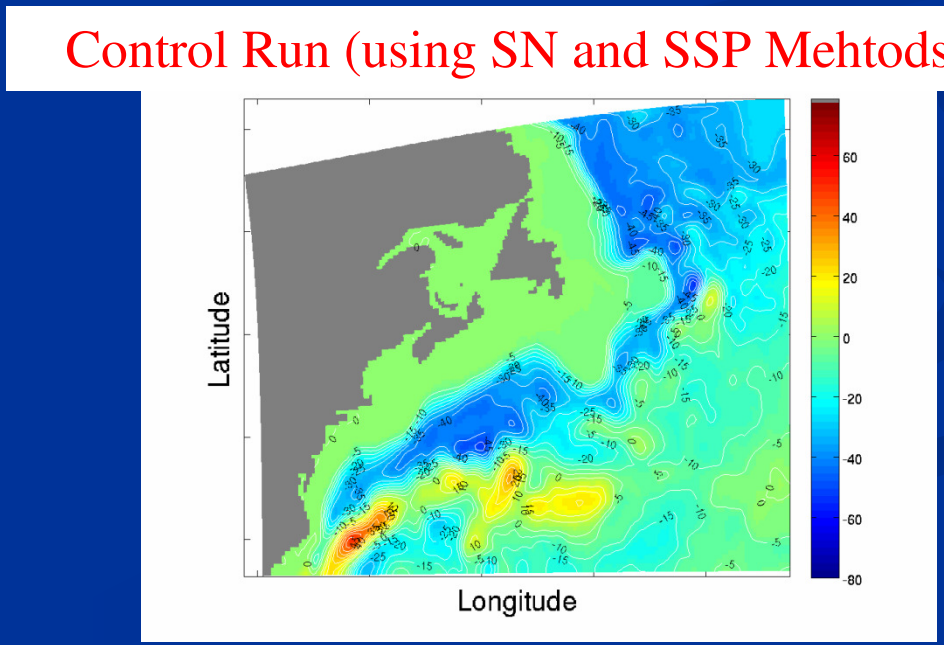




Annual mean transport streamfunction (Sv)



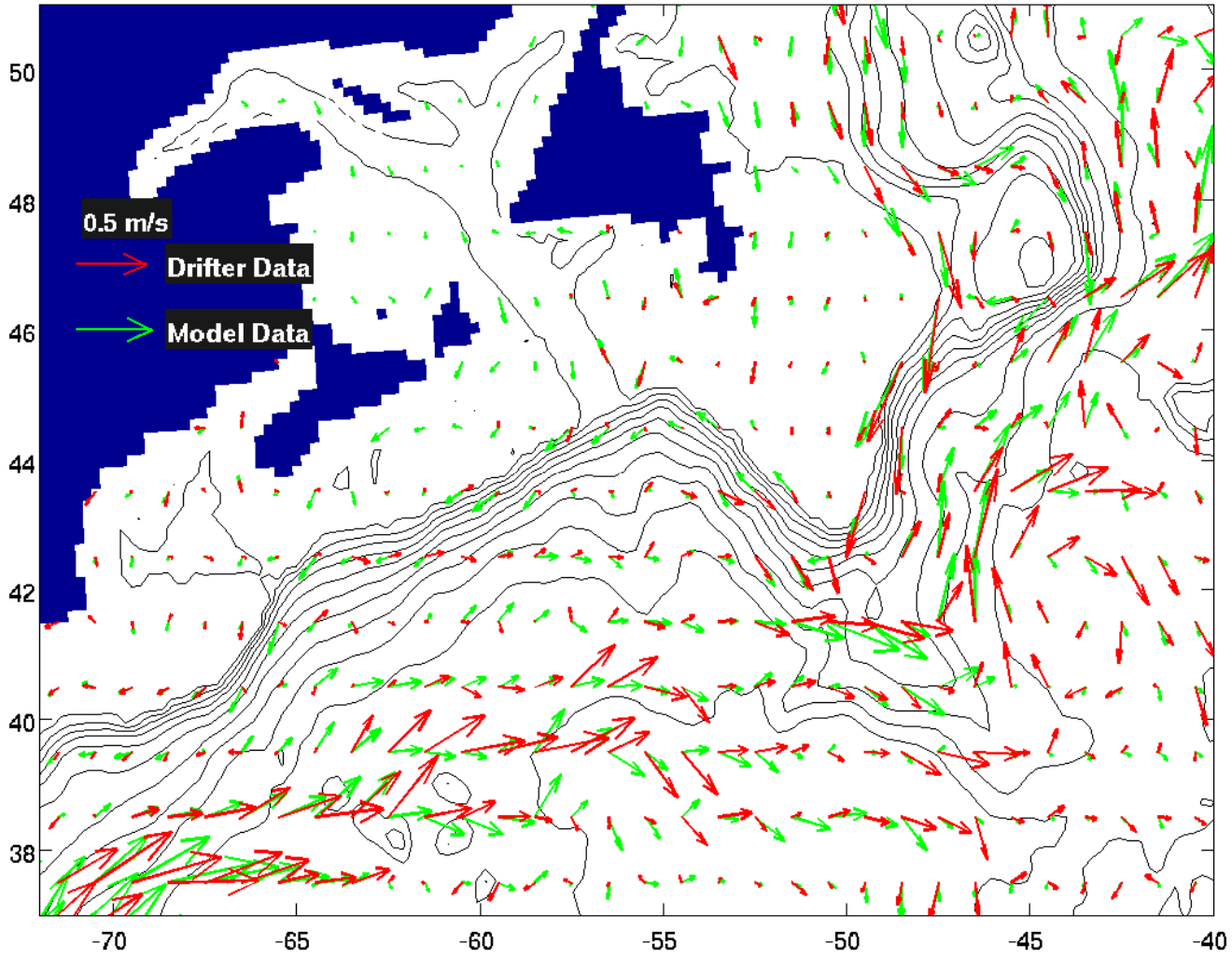




Time-mean currents (1996-2004) produced by the model

vs

Time-mean currents (1978-1999) inferred from drifter data (Niiler, 2001)



Summary

- A regional ocean circulation model was developed for the northern Atlantic Ocean, which will be the outer component of a nested-grid model for the eastern Canadian shelf.
- The combination of the spectral nudging method and smoothed semi-prognostic method with weaker correction terms is used in the model to reduce the model bias and drift.
- The model is forced by 6-hourly NCEP reanalysis data and 5-day model results produced by the BADC.