Study of Circulation and Variability in the Northwest Atlantic Ocean using a Numerical Model with the Spectral Nudging and Semi-Prognostic Methods

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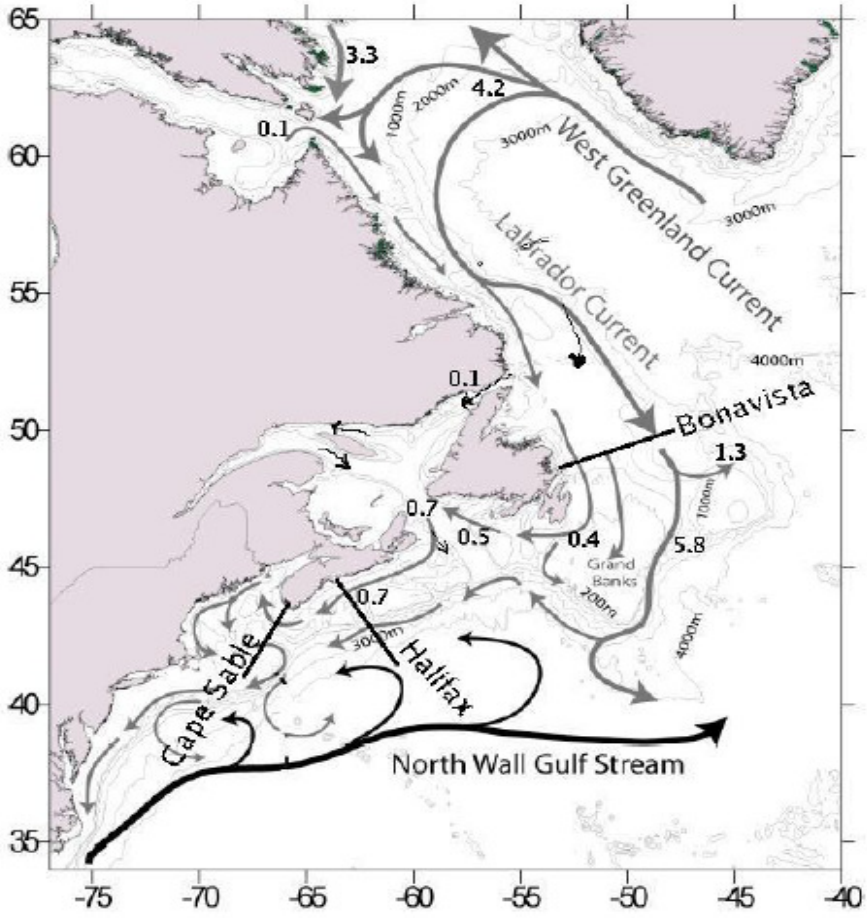
Outline

- Introduction and objectives
- Numerical circulation model of the northwest Atlantic Ocean based on NEMO
- Simulation of the interannual variability over the Scotian Shelf and adjacent Slope
- Summary

Introduction



(Loder et al.,1998)

- **Circulation and hydrography have significant variability in the region.**
- **Variability is related to fluxes, cross shelf exchanges, interaction between main circulation features.**
- **For the Scotian Shelf a decreasing SST trend has been observed during 1998-2008.**

Objectives

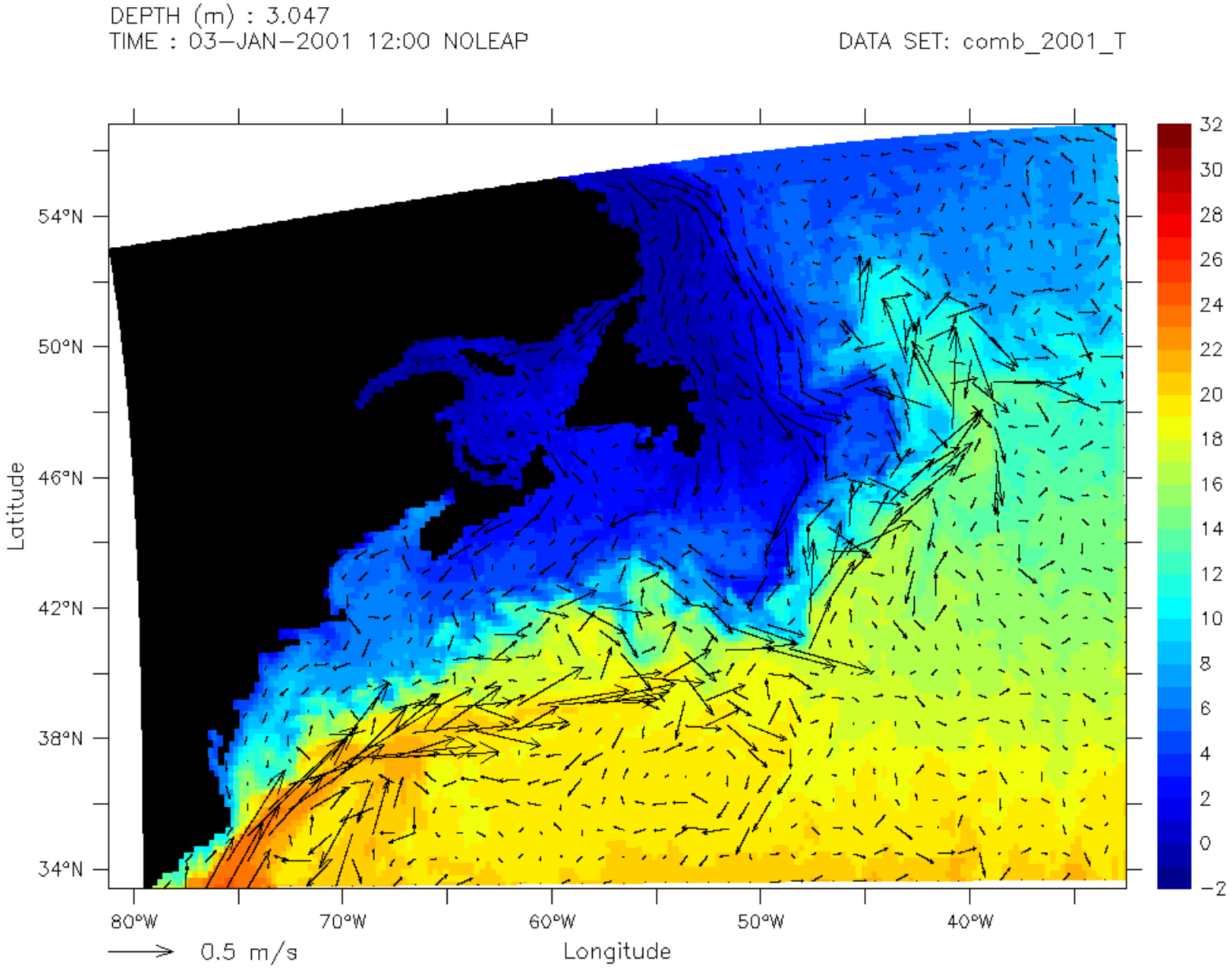
- **Use a 3-D baroclinic ocean circulation model to study temperature interannual variability over the eastern Canadian shelf**

- **Determine the main physical processes responsible for the observed negative SST trend over the Scotian shelf during 1998-2005.**

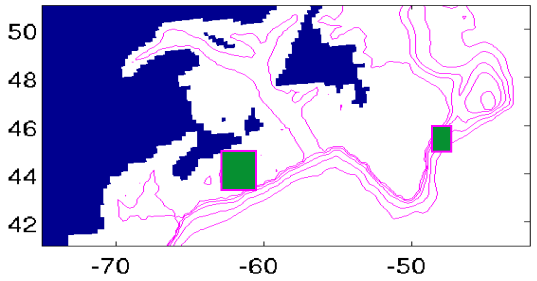
Main features of the model

- **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., 2006), and semi-prognostic method (Sheng et al., 2001).**
- **Forced by 6-hourly surface wind stress (NCAR/NCEP reanalysis data) and interannually varying surface heat and freshwater flux (Large and Yeager, 2009).**
- **Open boundary conditions are based on 5-day reanalysis data produced by the British Atmospheric Data Centre (BADC, RAPID project).**
- **The model is integrated for 17 years from 1988 to 2004.**

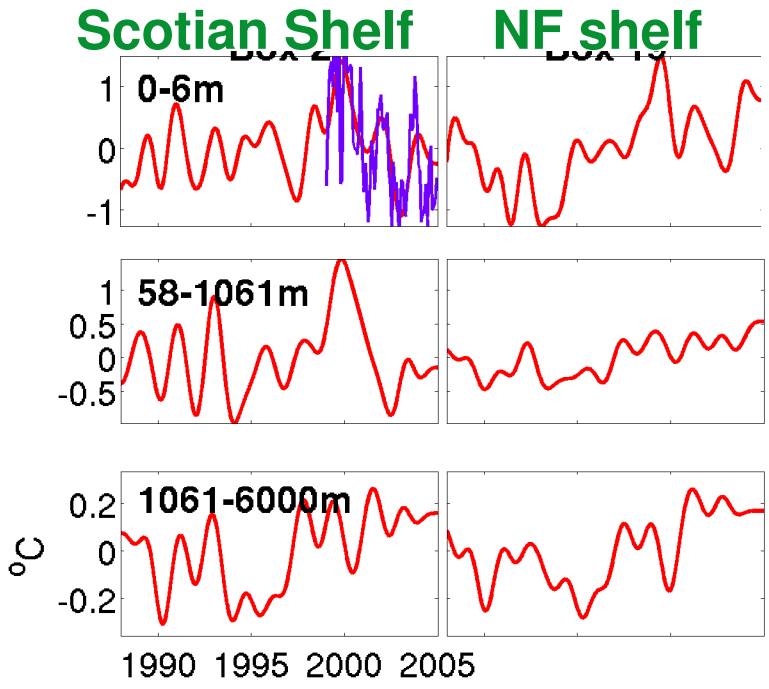
Near-surface temperature and currents over the northwest Atlantic (2001-2003)



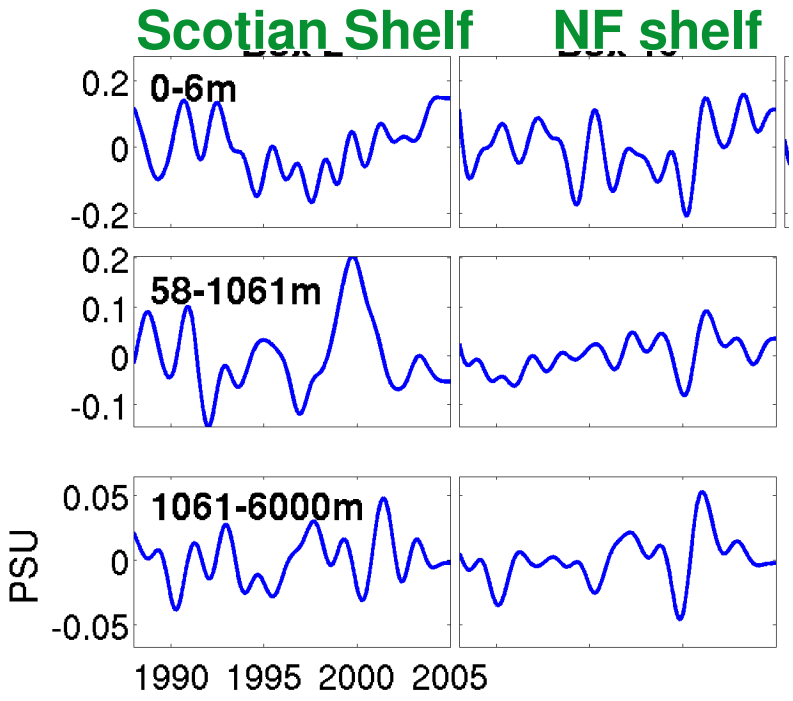
Interannual variability over the Eastern Canadian Shelf and Slope



Temperature anomalies



Salinity anomalies



Observed SST anomalies from satellite (Helmuth Thomas)

Four numerical experiments were conducted to examine interannual variability over the Scotian Shelf and Slope:

1. **Control run:**

   6-hourly wind speed, air temperature, specific humidity of the air, short and long wavelength radiation, Monthly precipitation

2. **Constant boundary forcing (CF):**

   18-year mean wind speed, air temperature, specific humidity of the air, short, long wavelength radiation and Temperature, Salinity and ocean currents at the open boundaries.

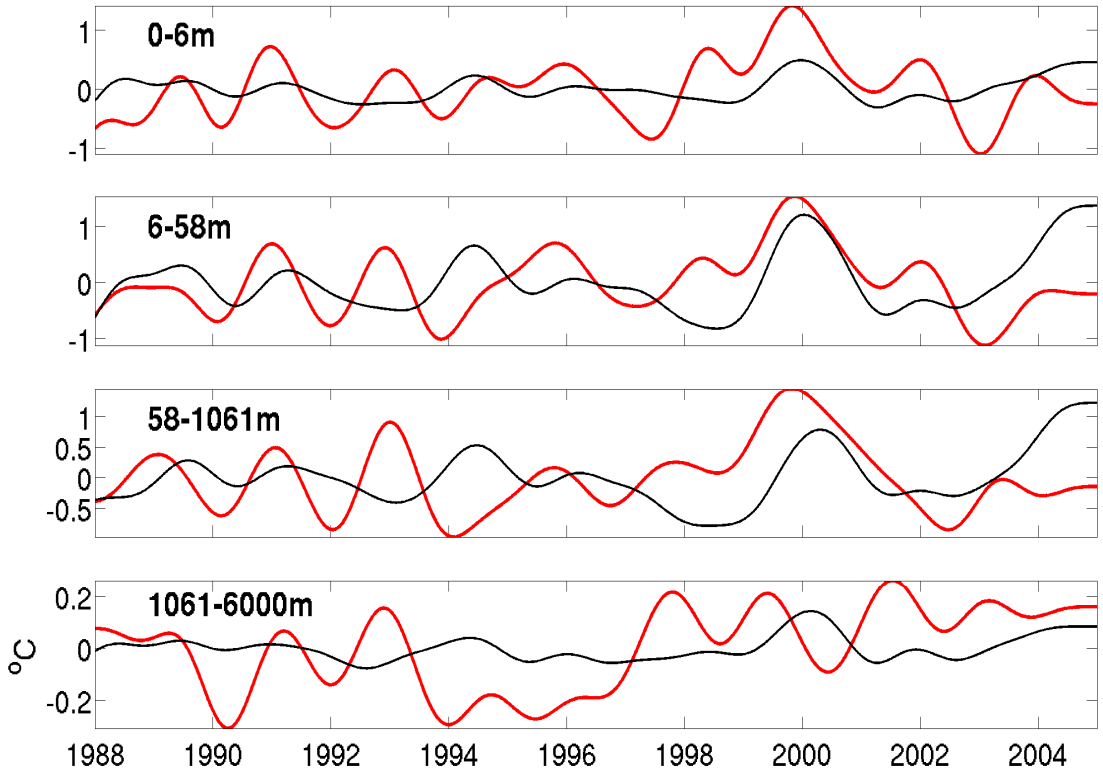
3. **Constant open boundary forcing (COBC)**:

   18-year mean Temperature, Salinity and ocean currents at the open boundaries.

4. **Constant surface net fluxes (CWF):**

   18-year mean wind speed, air temperature, specific humidity of the air, short and long wavelength radiation

Influence of the interannual variability of model forcing and internal dynamics



Model temperature anomalies (interannual) over the Scotian Shelf

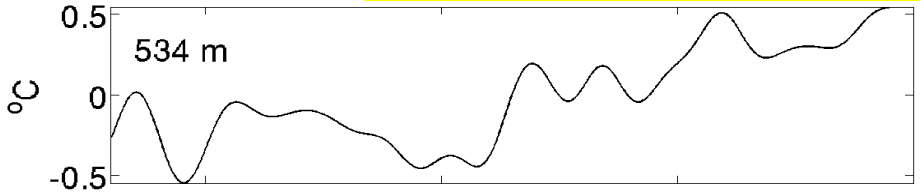
Interannual Forcing (Exp-CR)

Constant Forcing (Exp-CF)

- **Internal dynamics play an important role (Exp-CF)**
- **TS interannual variability is also affected by temporal variability of model forcing.**

Influence of interanual variability of lateral open boundary forcing

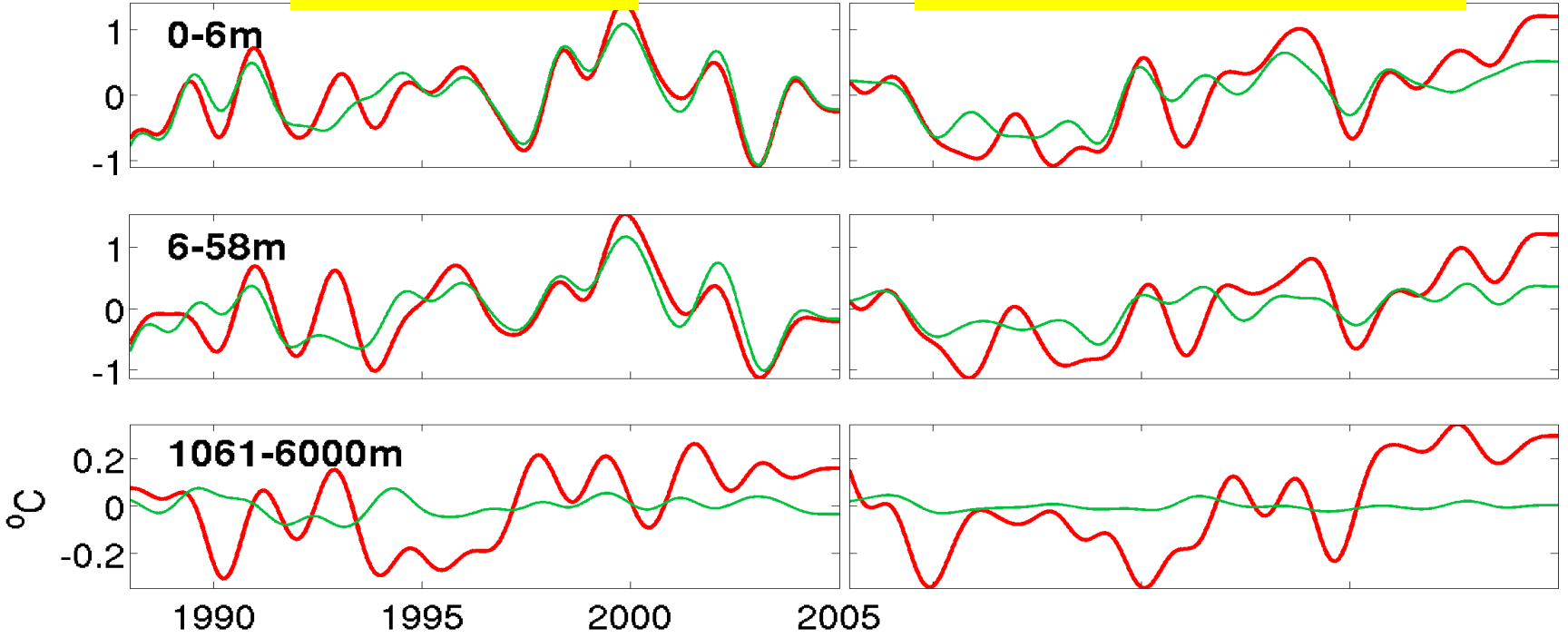
Labrador Shelf (BADC data)



Model temperature anomalies (interannual)

Scotian Shelf

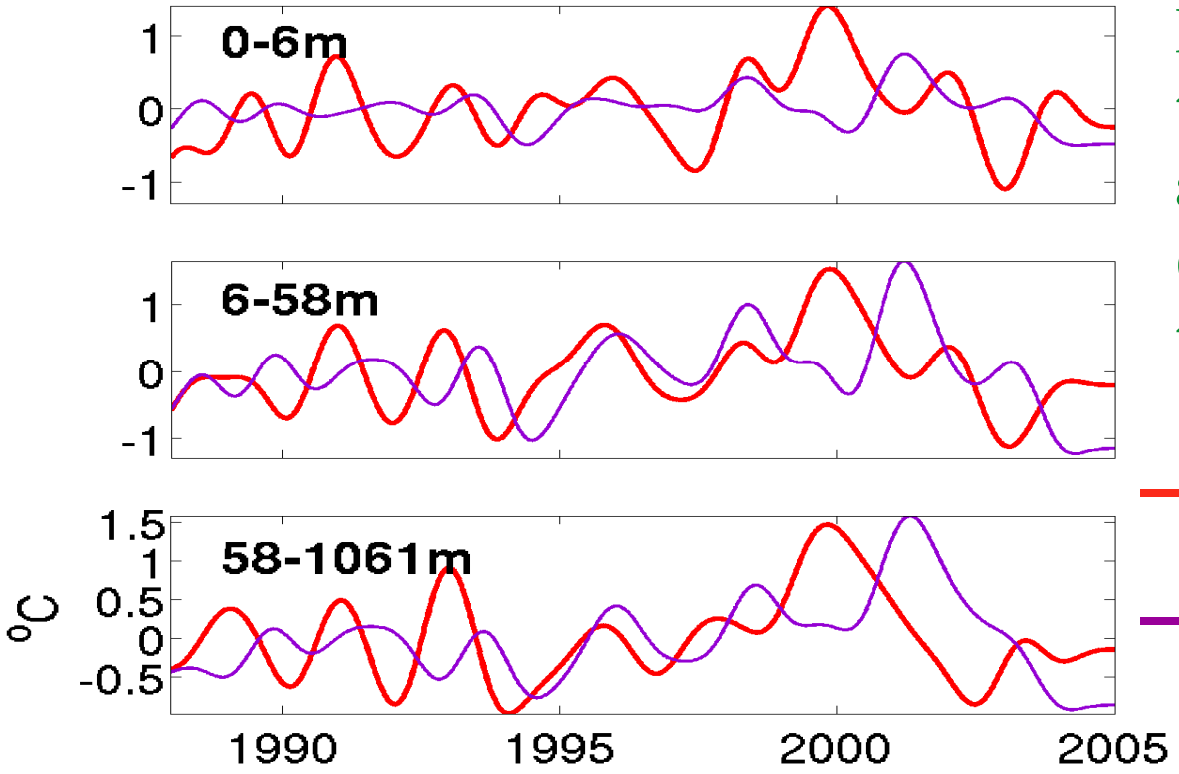
Newfoundland Shelf



Interannual Forcing (Exp-CR)

Constant OBC Forcing (Exp-COBC)

Influence of the interannual variability of the sea surface net heat/freshwater fluxes



Model temperature anomalies (interannual) over the Scotian Shelf

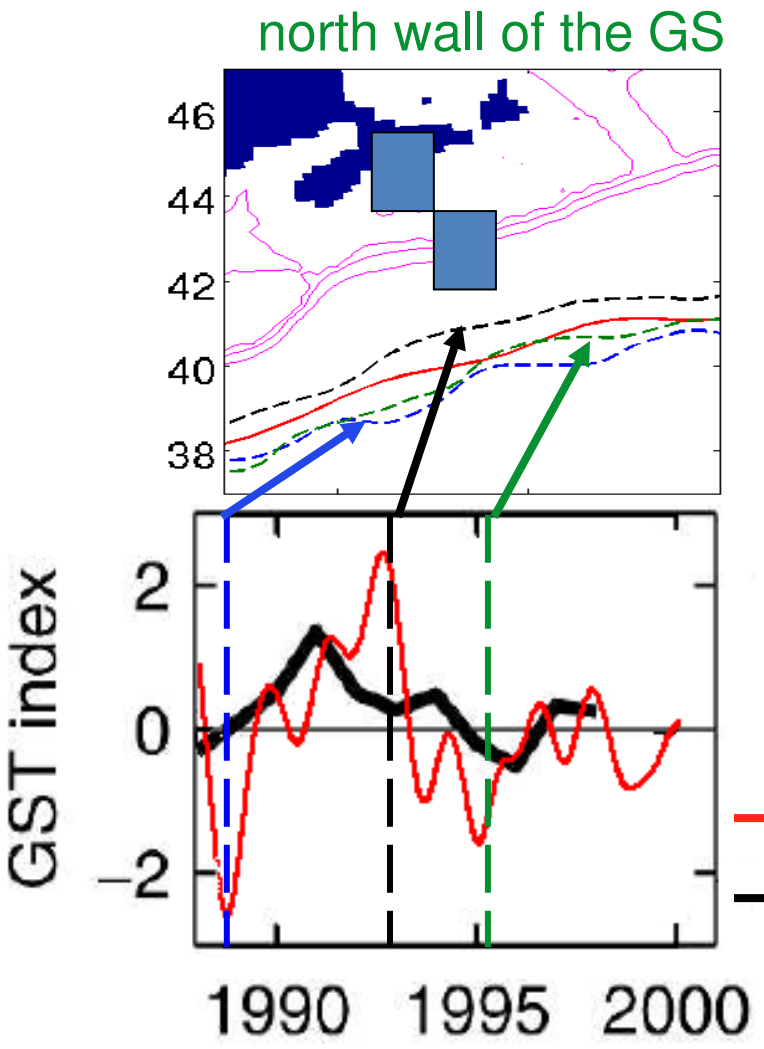
Interannual Forcing (Exp-CR)

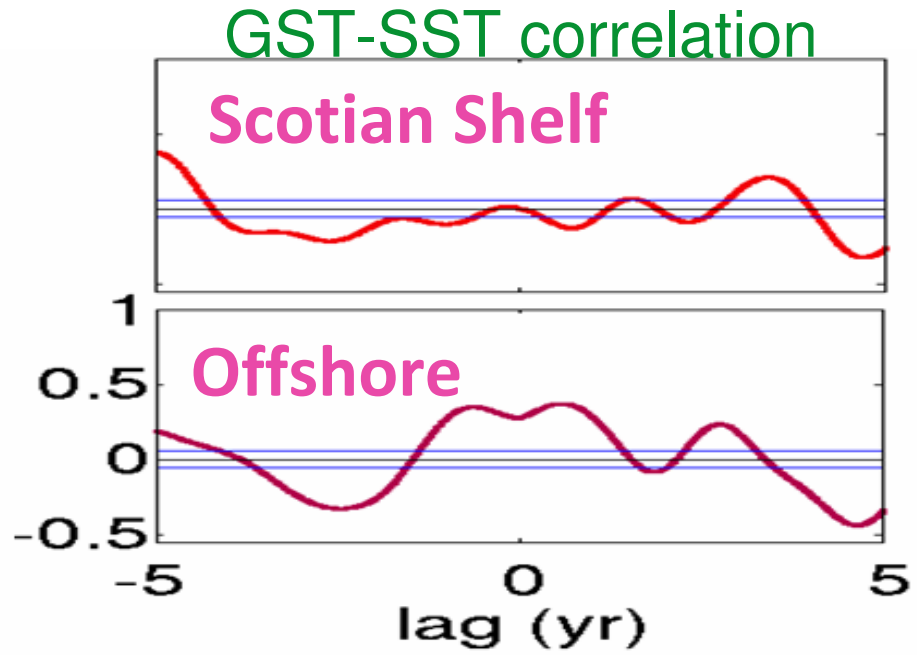
Constant Surface Forcing (Exp-CWF)

- **TS interannual variability in the upper ocean is affected by variability of net heat/freshwater fluxes at the sea surface but there are periods when this influence is rather weak.**

Influence of the position of the Gulf Stream on SST temperature anomalies

Gulf Stream position index (GST) calculated from positions of the GS north boundary (15ºC isotherm at 200 m between 55ºW and 68ºW).



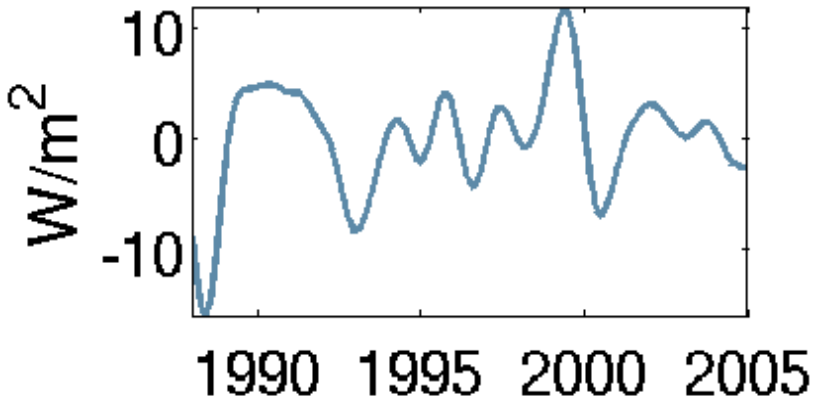


Simulated GST (this study)

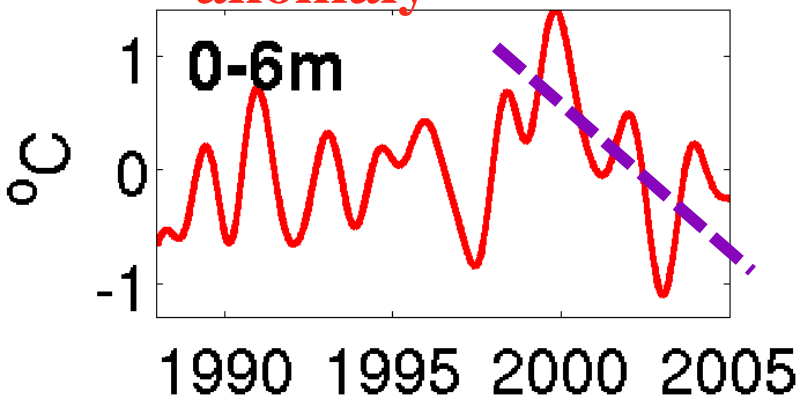
Simulated GST (de Coëtlogon et.al. 2006)

Cooling trend (1998-2005) at the surface over the Scotian Shelf is most likely linked to air-sea heat exchange

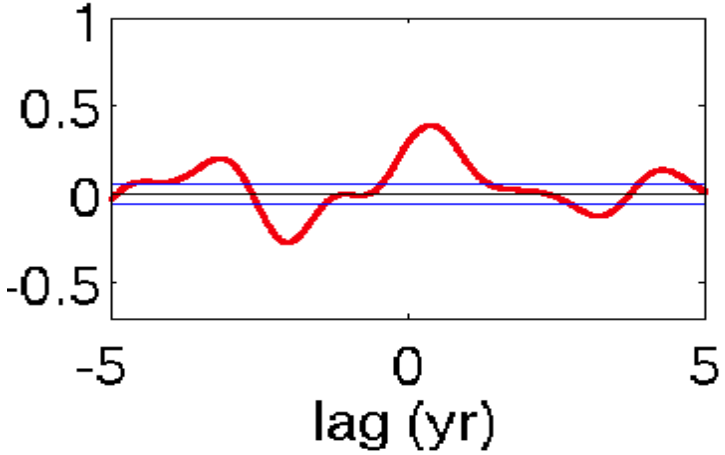
Short wavelength radiation anomaly



Model temperature anomaly



correlation



Summary

- A 3D ocean circulation model based on NEMO was developed for the northwest Atlantic and applied in a process study of interannual variability over the eastern Canadian shelf with focus on the Scotian Shelf and Slope.
- There are significant interannual variabilities in model hydrography over the entire water column over the Scotian Shelf and slope.
- Preliminary model results demonstrate that the upper ocean temperature interannual anomalies are affected more by interannual variability of heat and freshwater fluxes and internal dynamics.
- For intermediate and deep waters over the Scotian Shelf and slope the interannual variability is affected largely by the Labrador Current.