MODELING THE CROSS-MARGIN EXCHANGES AND INTERACTIONS BETWEEN COASTAL AND DEEP-OCEAN

Germana Peggion
Institute of Marine Sciences, The University of Southern Mississippi
Bldg. 1103, Rm 249, Stennis Space Center, MS, 39529
ph: (228)688-2897, fax: (228)688-7072, e-mail: germana.peggion@usm.edu

Award #: N00014-96-1-0937

LONG-TERM GOALS

The specific goals are toward the understanding of the physical mechanisms that control the shelf, shelf/break, and slope dynamics and the cross-margin interactions between the coastal and deep-ocean regions.

OBJECTIVES

- to evaluate whether a moderately parallel processing environment is suitable for the development of two-way communication schemes between the large-scale basin and the high-resolution coastal models;
- to understand and model the interaction between the deep and shallow waters and the mechanisms through which the shelf and open ocean exchange mass and momentum;
- to understand and model the intrusion of Loop Current (LpC) over the Mississippi Bight (MB) and determine the role of the Desoto Canyon in the cross-margin processes.

APPROACH

The approach is to implement a two-way nesting procedure between large-scale basin and high-resolution coastal models. The problem is formulated by assuming that there are two dominant scales: the small, energy-containing features and the large, slowly-varying flow. The algorithms are implemented under the condition that the coarse domain extends over the fine grid, so that the coastal model is forced at the interface by the large-scale flow and a feedback procedure is applied to the overlapping basin area.

WORK COMPLETED

The Princeton Ocean Model (POM) is the model of choice for the development of the nesting procedure. The numerical algorithm is robust, physically accurate, easily relocatable, and computationally efficient. The modular code architecture makes it possible for new components to be included with little additional programming

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1999**	2. REPORT TYPE	3. DATES COVERED **00-00-1999 to 00-00-1999**
4. TITLE AND SUBTITLE **Modeling the Cross-Margin Exchanges and Interactions Between Coastal and Deep-Ocean**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Southern Mississippi,Institute of Marine Sciences,Bldg 1103, Room 249,Stennis Space Center,MS,39529**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT **unclassified**	b ABSTRACT **unclassified**	c THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

for implementing the interface communications.

Intrusions of the LpC over the coastal areas have been analyzed as a function of several data sets:

- Bathymetry (ETOP05 and MMS-GOM101)
- Winds: 1) Hellerman-Rosentein monthly climatlogy, 2) MMS monthly climatology and 3) ECMWF-1993 6 hour winds.
- Heat fluxes from CODAS
- Temperature and salinity fields from 1) Levitus and 2)MMS climatology.

The MMS data sets have been developed by Dynalysis of Princeton (Herring et al., 1999). The ECMWF winds and CODAS Heat fluxes were acquired from the DAMEE-NAB data sets.

As expected, winds have little influence in determing the large-scale features (such as ring separation and migration) of the basin model. On the other hand, operational (not-climatological) winds are an important factor for reproducing an appropriate coastal circulation, with more marked currents and jets. It is found that a realistic bathymetry is essential for a correct orientation and more marked northward penetrations of the simulated LpC axis. Under these conditions, an almost-permanent cyclonic eddy develops off-shore of the Big Bend region. This feature is well documented by TOPEX/ERS-1 satellite images (Biggs et al., 1996).

RESULTS

The MB has great topographic variations: though wide, it narrows near the DeSoto canyon and the Mississippi delta closes the shelf to the west leaving only a narrow passage that connects the western and eastern side of the northern shelf. This configuration has a great effect on the along-shore wind-driven circulation that dominates the inner shelf (Schroeder et al., 1987). Transport conservation requires high spatial variability of the currents, providing more energy available to enhance coastal front instabilities. The instabilities are associated with meander and eddy formations, and front breaks with considerable exchange of mass and momentum between shelf and deep ocean.

The numerical simulations are able to reproduce the interactions between the shallow and deep waters at the shelf break, and over the continental slope as observed and described by Kelly (1991). When warm and salty water from the open Gulf approaches the MB and moves along the DeSoto Canyon, it has the tendency of becoming unstable. The high-resolution nested model clearly indicates the genesis of filaments and mushroom-like features that usually entrain cold and fresh coastal waters. As the deep water intrusion regresses, these small cyclonic eddies are carried away from the coastal region, contributing to the shelf-deep ocean exchanges. The genesis and evolution of these features have been observed and documented by satellite imagery (Leben, 1999)

Due to a general westward tilting of the LpC axis, and the presence of a quasi-permanent cyclonic eddies off the Florida Big Bend, intrusions of warm and salty waters are usaully from the west. The gulf water flows parallel to and interacts with the coastal jet, and recirculates backward, carrying cold eddies along the eastern side of the canyon. However, eastern penetration of LpC waters have been equally observed and reproduced by our model simulations (Fig. 1).

Because of the coarse resolution of the GOM model, we are not able to track the fate of the shelf water entrained in the LpC outer edge as it leaves the nested domain. Satellite imaginery, and oceanographic observations suggest that shelf water does not mix with the surrounding environment; traces of it have been found along the West Florida Coast and through the Florida Strait (Maul, 1997).

Although the coastal front oscillates and meanders everywehere along the shelf break, the DeSoto Canyon enanhces the instability. The topographic variations speed up the genesis and formation of eddies and meanders, modulating the spatial and temporal scale of the mesoscale variability (Chapman and Gawarkiewicz, 1995). Moreover, topographic features induce an asymmetric bottom stress that may generate substantial time-averaged currents even in the presence of zero-mean fluctuations (Haidvogel and Brink, 1986). This source of energy enhances the coastal front instability.

During a one year simulation, mooring stations have been simulated along the 500m isobath in the proximity of the canyon's head. All stations indicate high variability at the surface and mid-column. Surface and mid-column have high correlations coefficients, while the bottom is usually out of phase with respect to the upper strata. Although intrusion of shelf waters are found at each station, the coldest and saltiest waters are reported at the head of the canyon.

In agreement with observations and the previous studies, the numerical simulations indicate that the DeSoto Canyon is the location at which most of the cross-margin exchanges occurr. Northward intrusions at the surface and mid-depth from the open ocean are usually compensated by an offshore movement of dense shelf water down into the Canyon.

IMPACT/APPLICATIONS

This research addresses relevant issues for the Navy's operational activities on littoral regions. It provides:

- a modeling approach for the coastal areas that takes into account the mutual interactions between shallow and deep waters (i.e., physically accurate);
- a coupled system which is computationally efficient and higly portable (i.e., cost effective and easily reconfigured for other coastal regions);
- evaluation of whether moderately parallel environments are suitable for ocean applications (i.e., in line with the new computer technologies).

TRANSITIONS

This project provides a transition of knowledge and nesting techniques to be used in other coastal modeling applications. Data have also been transfer to the NRL-SSC acoustic group to test and evaluate 3-D acoustic models over coastal areas.

RELATED PROJECTS

This program fits well with the DoD High Performance Computing Modernization Office interests in developing scaleable ocean and atmospheric modeling applications.

Under the sponsorship of the MMS, a multi-year hydrographic survey program is in progress in the DeSoto Canyon area and Northeastern Gulf. At the University of Colorado, R. Leben (1999) has developed and is maintaining a nearly real-time database of TOPEX/ERS-2 altimetry data. Both programs provide a valuable set of data and measurements for our model initialization and model-data comparison.

REFERENCES

Biggs, D.C., G.S. Fargion, P. Hamilton, and R.R. Leben, 1996: Cleavage of a Gulf of Mexico Loop Current Eddy by a Deep Water Cyclone. *J. Geophys. Res.*, **101**, 20,629-42.

Chapman D.C. and G. Gawarkiewicz; 1995: Offshore transport of dense shelf water in the presence of a submarine canyon. *J. Geophys. Res.*, **100**, 13373-87.

Haidvogel, D.B. and K.H. Brink; 1986: Mean current driven by topographic drag over the continental shelf and slope. *J. Phys. Oceanogr.*, **16**, 2159-71.

Herring, H.J., I. Masamichi, G.L. Mellor, C.N.K. Mooers, P.P. Niiler, L.Y. Oey, R.C. Patchen, F.M. Vukovich, and W.J. Wiseman; 1999: *Coastal ocean modeling program for the Gulf of Mexico*. Dynalysis of Princeton. Report 115.

Kelly, F.J., 1991: Physical Oceanography and water mass characteristics. In *Mississippi-Alabama Continental Shelf Ecosystem Study. Data and synthesis*. US Dept. of the Interior. Minerals Managment Service. Gulf of Mexico OCS Region.

Leben R.R.; 1999: Gulf of Mexico Web Sites. Document available at: http://www-ccar.colorado.edu/ leben/gom/websites/

Maul, G.A.; 1977: The annual cycle of the Loop Current. Part I: Observations during one year time series. *J. Mar. Sci.*, **35**, 29-47.

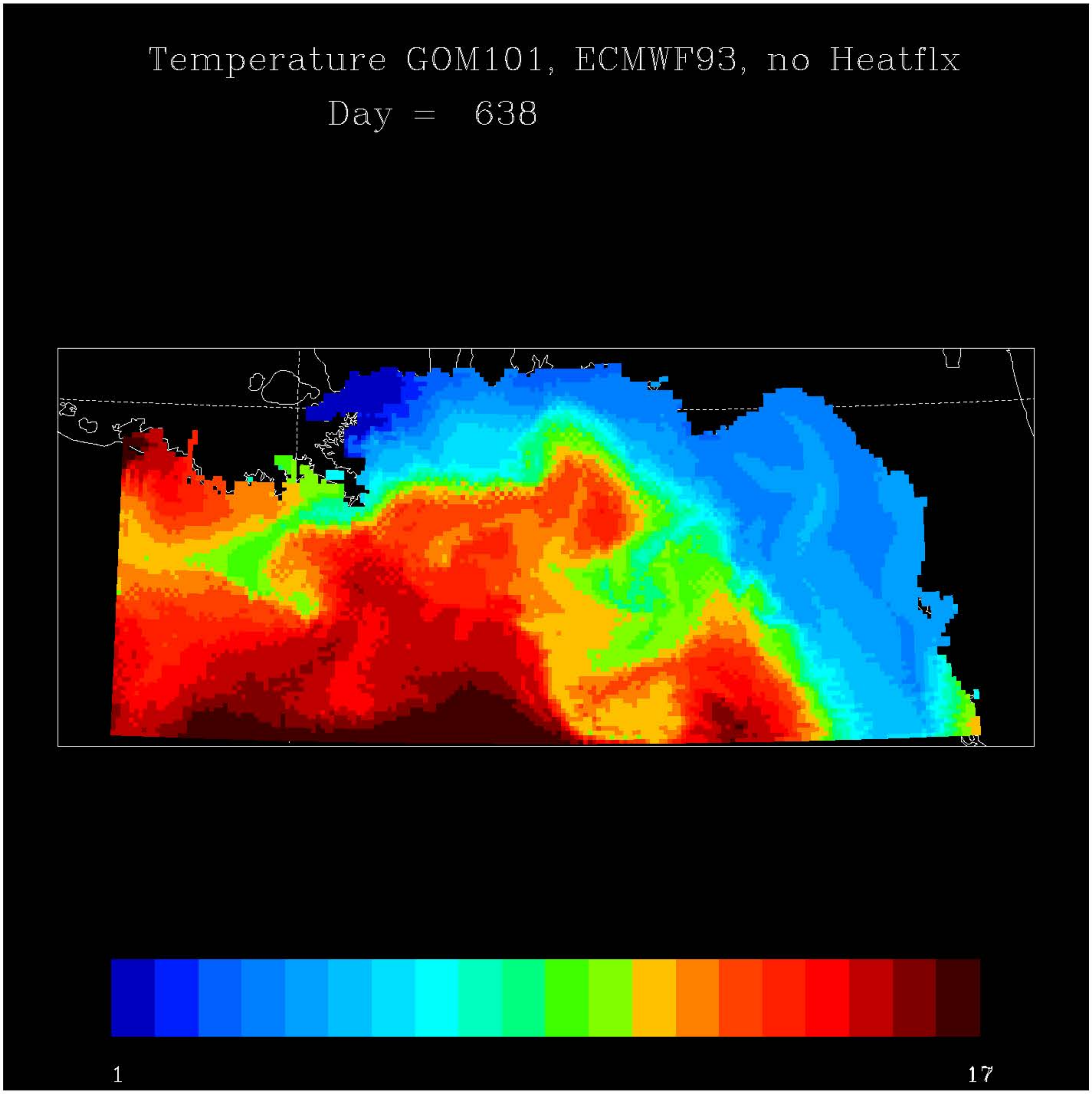
Schroeder W.W., S.P. Dinnel, W.J. Weisman, and W.J. Merrell; 1987: Circulation patterns inferred from the movement of detached buoys in the eastern Gulf of Mexico. *Cont. Shelf Res.*, **7**, 883-94.

PUBBLICATIONS

Gallacher P. and G. Peggion, 1999: Air-sea feedback during coastal upwelling. Submitted to *J. Phys. Oceanogr.*.

Peggion G.; 1999: A two-way nested model for the Northeastern Gulf of Mexico on a moderately parallel environment. *Proceeding of the DoD HPC Users Group Conference*. Monterrey, Ca. June 7-10, 1999. In Press.

Peggion G.; 1999: Intrusion of the Loop Current over the MS Bight. Submitted to *Proceeding of 6 th International Conference on Estuarine and Coastal Modeling*, New Orleans, LA, November 3-5, 1999


Temperature GOM101, ECMWF93, no Heatflx
Day = 638
1
17