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2002-09

Nonhydrostatic Modeling of West Florida Shelf Flow

Garwood, Roland W. Jr.; Harcourt, Ramsey H.

http://hdl.handle.net/10945/68954

Nonhydrostatic Modeling of West Florida Shelf Flow and Tracers

Roland W. Garwood, Jr., Professor
Department of Oceanography
Naval Postgraduate School
Monterey, CA 93943
Phone: 831-656-3260 fax: 831-656-2712   email: garwood@nps.navy.mil

Ramsey Harcourt, Research Assistant Professor[1]

Document Number: N0001401WR20396
http://www.oc.nps.navy.mil/opbl/
http://www.oc.nps.navy.mil/opbl/my4413movie.gif

LONG-TERM GOALS

The long range scientific goal of the Oceanic Planetary Boundary Layer (OPBL) Laboratory is to understand the role of the OPBL in the coupled exchange of energy, momentum and mass between the upper ocean and the atmosphere (and the cryosphere).

OBJECTIVES

The objective of the research here is to calculate nonstationary three-dimensional solutions for the turbulent nonhydrostatic flow regime on the West Florida shelf using Large-Eddy Simulation. These solutions are used to explain the three-dimensional optical properties of the water column by understanding the behavior of tracers and drifters deployed during field experiments.

APPROACH

Mathematical models for turbulent entrainment, shear production, buoyancy flux, transport and dissipation are developed and verified by comparison with observations and full-physics nonhydrostatic large-eddy simulation (LES). Coupling with atmosphere and/or cryosphere is included and is intrinsic to system prediction. Turbulent processes found to be of importance to the coupled system are parameterized for implementation in hydrostatic OGCM's for research and operational use.

WORK COMPLETED

During FY02, the OPBL Laboratory of the Naval Postgraduate School carried out numerical solutions for the turbulent nonhydrostatic flow regime on the West Florida shelf using Large-Eddy Simulation. These solutions can now be used to explain the optical properties of the water column by understanding the behavior of tracers and drifters deployed during field experiments with AUV's. The solutions for the turbulent flow on the shelf are contrasted with the turbulent flow solutions for the deep ocean, including the Labrador Sea. Animated GIFS of the turbulent boundary layer in both shelf

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[1] Presently at Applied Physics Laboratory, University of Washington, Box 355640, Seattle, WA 98105; harcourt@apl.washington.edu

1. REPORT DATE **30 SEP 2002**	2. REPORT TYPE	3. DATES COVERED **00-00-2002 to 00-00-2002**
4. TITLE AND SUBTITLE **Nonhydrostatic Modeling of West Florida Shelf Flow and Tracers**		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) **Department of Oceanography,,Naval Postgraduate School,,Monterey,,CA, 93943**		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
The long range scientific goal of the Oceanic Planetary Boundary Layer (OPBL) Laboratory is to understand the role of the OPBL in the coupled exchange of energy, momentum and mass between the upper ocean and the atmosphere (and the cryosphere).

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)**	**4**	

and deep ocean regimes have been produced with the assistance of NRC Postdoctoral Associate, Pascale Lherminier.
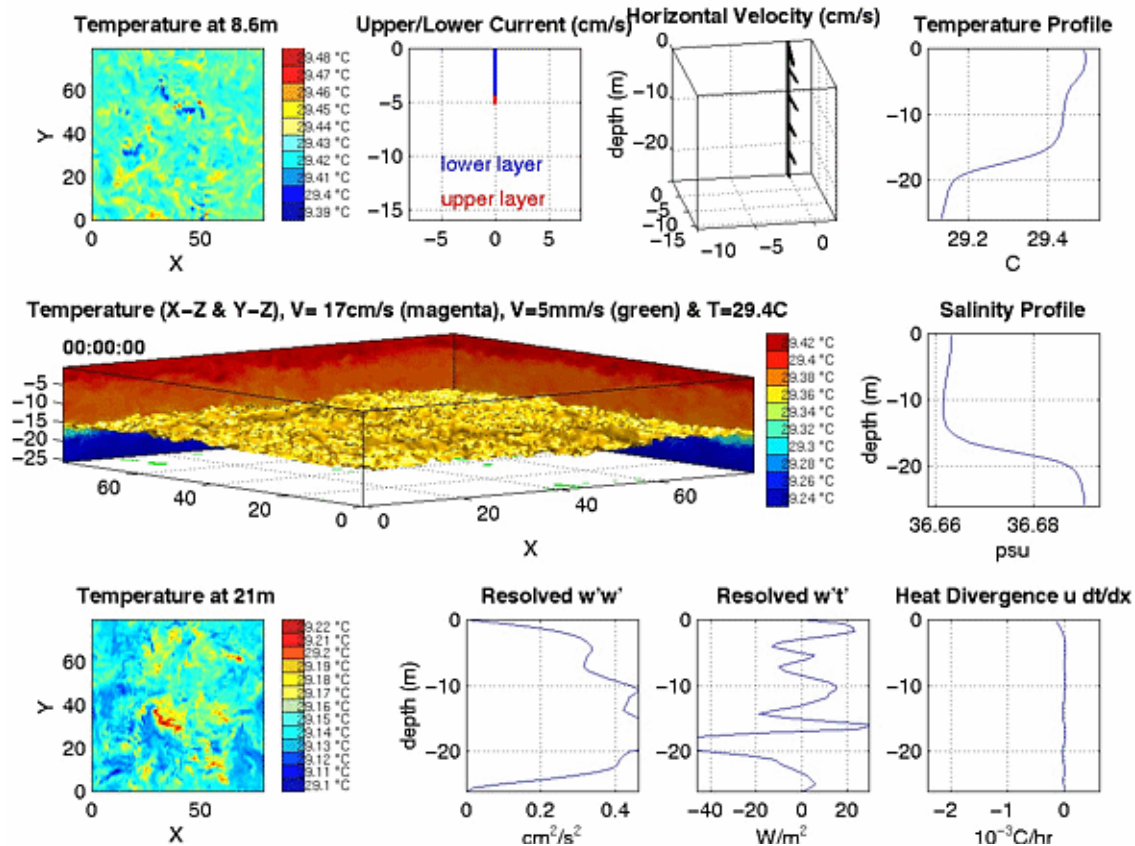
Figures 1-10: (1) Color-coded temperature structure at 8.6m, dominated by wind-driven Langmuir cells approximately parallel to the surface wind; (2 and 3) Alternate vector portrayals of the horizontal flow. A vertical shear develops at the interface, which is caused by the growth of wind-driven current in the surface layer. This includes a transient inertial component that may be the source of internal waves and shear instability after the top layer becomes well-mixed; (4) T(z,t); (5) S(z,t); (6) Vertical kinetic energy, $\overline{w'w'}(z,t)$. This is mostly turbulent kinetic energy in the upper layer, but it is dominated by internal wave kinetic energy at mid-depth; (7) Vertical heat flux, $\overline{w'T'}(z,t)$. The value of $\overline{w'T'}$ is consistently negative in the upper layer, indicating active entrainment mixing. Its value fluctuates in sign near the interface because the internal waves accomplish no significant mixing until possibly later in the evening; (8) Horizontal advection of T. This is realistic but small, contributing little to the intensity of the fine scale features; (9) Color-coded temperature at 21 m, dominated by eddies produced by bottom shear; and (10) A 3-D picture of iso-temperature and iso-velocity structures that portray internal waves on the interface near 18 m, and highly intermittent patches of Reynolds stresses just above the bottom and below the surface.

RESULTS

These animations have been most useful in displaying the three-dimensional unsteady evolution of the turbulent fluxes and turbulent kinetic energy attributable to different boundary conditions: forced convection caused by wind stress and bottom drag and to free convection associated with surface cooling. Sequential Figures 1-10 above illustrate a gif that may be animated by setting the URL of your browser to http://www.oc.nps.navy.mil/opbl/my4413movie.gif . The temperature and salinity were initiated with one of the USF WFL Shelf CTD casts from last year. There was a substantial 2-layer system, with a 0.5 C and 0.03 psu interface at about 18-m depth. There was also a shallow (4 m) transient temperature-controlled (0.05 C) near-surface mixed layer, which was subsequently eroded away by wind-induced entrainment after sunset. The initial velocity is geostrophic and barotropic, corresponding to climatology. Forcing was from a steady 9-m/s wind from the north, with negligible surface heat flux, corresponding to conditions in the late afternoon and into the evening.

IMPACT/APPLICATIONS

The results portrayed in this movie highlight the realistic fine structure evident in large-eddy simulation for several hours at 26-m deep site on the West Florida shelf after a day of diurnal heating. The nonhydrostatic convection and internal waves show clearly why and when eddy mixing coefficients in hydrostatic models may be seriously inadequate for predicting stratified coastal flows.

PUBLICATIONS

Ly, L. N. and R. W. Garwood, Jr., An Ocean Circulation Model With Surface Wave Parameterization, *Applied Numerical Mathematics*, **40**, 351-366, 2001.

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