LES Modeling of Lateral Dispersion in the Ocean

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Award Number: N00014-09-M-0214

FINAL REPORT

LONG-TERM GOALS:

The long-term goal of this effort is to work in concert with DRI participants to develop scalable, physically based parameterizations for lateral mixing in the stratified ocean on scales of 0.1-10km that can be implemented in larger-scale ocean models. These parameterizations will incorporate the effects of local ambient conditions including latitude, mean stratification and mesoscale flows. Another ultimate goal is to develop a more comprehensive picture of horizontal and vertical mixing processes in the ocean in collaboration with other DRI participants.

OBJECTIVES:

The objective is to participate in the multi-year, concerted DRI effort of field observations, theoretical and numerical modeling on oceanic small-scale lateral dispersion. Mesoscale flows of interest include internal tides, near-inertial waves, ocean fronts and mesoscale eddies.

APPROACH:

As a numerical modeler, my approach consists of using my primary numerical tool, a highly optimized Boussinesq model that has been extensively used to study internal-wave and dispersion-related problems.

WORK COMPLETED DURING THIS PROJECT:

In June 2009, I attended an ONR general meeting in Chicago and gave a presentation on my research on June 9 (file attached). The focus of my research this summer was two-fold: One aspect consisted of analyzing the energetics of wave breaking events. The purpose of this study was to quantify the amount of mixing, and hence the amount of potential energy that is converted to kinetic energy in the form of submesoscale vortices. The other aspect was to perform high-resolution simulations in the strongly nonlinear regime in order to quantify the contribution of small-scale vortices to the overall enstrophy cascade.
In December, I attended the DRI yearly meeting in Seattle. Joshua Jacobs, a PhD candidate who is also being funded by this grant, also participated in the Seattle meeting. Our efforts continue to be focused on understanding the characteristics of submesoscale vortex flows resulting from wavebreaking events. I have begun considering the impact of mesoscale vortices on submesoscale lateral dispersion. The initial flow consists of a field of spun up mesoscale turbulence. The flow is then forced as before with

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
12-07-2010

2. REPORT TYPE
Final Report

3. DATES COVERED *(From - To)*
5/7/2009 – 6/08/2010

4. TITLE AND SUBTITLE
LES Modeling of Lateral Dispersion in the Ocean

5a. CONTRACT NUMBER
N00014-09-M-0214

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Marie-Pascale Lelong

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER
ONR S973P Final Report

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
Attn: Theresa Paluszkiewicz
Ballston Tower One
875 N. Randolph St., Suite 1425
Arlington, VA 22203-1995

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

A

13. SUPPLEMENTARY NOTES

14. ABSTRACT
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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified	UL	2	

randomly placed (parameterized) wavebreaking events. I am currently examining the behavior of individual wavebreaking events placed in strain-dominated or shear-dominated regions.
J. Jacobs showed that modeling the distribution of wavebreaking events as a Poisson process leads to much more energetic submesoscale fields. This can be explained by the fact that closely spaced vortices are more likely to interact, and hence to merge. This merging results in an inverse cascade to larger scales. Hence, less energy is available for transfer to dissipative scales. We are currently attempting to quantify the energy transfer to the mesoscale from the wavebreaking events.

Tools based on a normal-mode decomposition were developed to facilitate the extraction of wave and vortical modes from numerically generated data. In addition to providing information about wave/vortical mode energies, these tools also enable us to examine energy transfers between the two components. We also examined energy cascade features. We find that when the Rossby number is of order 1 and the Froude number is below a critical value of .25, an inverse cascade is set up which transfers energy to modes characterized by strong vertical shear, no vertical velocity and no vertical vorticity.