

LES Modeling of Lateral Dispersion in the Ocean on Scales of 10m -10km

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LONG-TERM GOALS

The long-term goals of this research are to gain an understanding of the dynamical processes that govern small-scale lateral dispersion in the ocean on scales of 10m-10km, and to use this knowledge to develop and implement parameterizations for regional-scale ocean models. This project represents one of several numerical modeling efforts in the framework of the ONR DRI focused on submesoscale lateral dispersion.

OBJECTIVES

The primary objective of this project is to understand the impact of small-scale vortices produced by geostrophic adjustment following wave breaking events. Several aspects of this problem are being considered, including the influence of larger-scale vortices on the submesoscale vortices, the role of mean shears, and of near-inertial waves.

APPROACH

Process numerical simulations in idealized deep ocean environments (away from boundaries or topography) are performed with a three-dimensional pseudo-spectral code (Winters et al. 2003). The model is run at high resolutions on parallel platforms including a Linux cluster and DoD supercomputers.

WORK COMPLETED

Funding for this project only became available in mid-June. Consequently, the work discussed in this report is very much work in progress. Focus has been on understanding the characteristics of turbulent fields produced by ensembles of wave breaking events. In particular, we would like to understand if and how this type of turbulence differs from turbulence that is generated by different mechanisms. The goal is to obtain quantitative estimates of spectral fluxes that can be compared to the spectral fluxes that result from other submesoscale energy sources such as frontal and ageostrophic instabilities. The spectral energy fluxes that we obtain will ultimately be compared to the fluxes estimated by the other

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participants in the Lateral Mixing DRI and will help us assess the relative contribution of adjustment-driven turbulence to lateral mixing rates on scales of 0.1-10km in the ocean.

RESULTS

We do not yet have any quantitative results to report. Over the summer, the numerical code was successfully ported to a Linux cluster and we have begun performing simulations and examining the statistics and structure of the simulated turbulent fields. Below are two snapshots of horizontal and vertical cross-sections of turbulent fields generated by an ensemble of parameterized wave-breaking events.

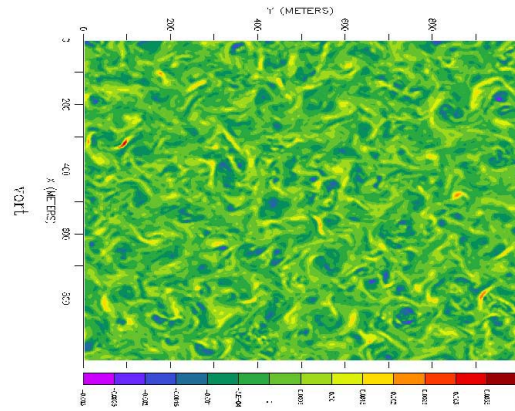
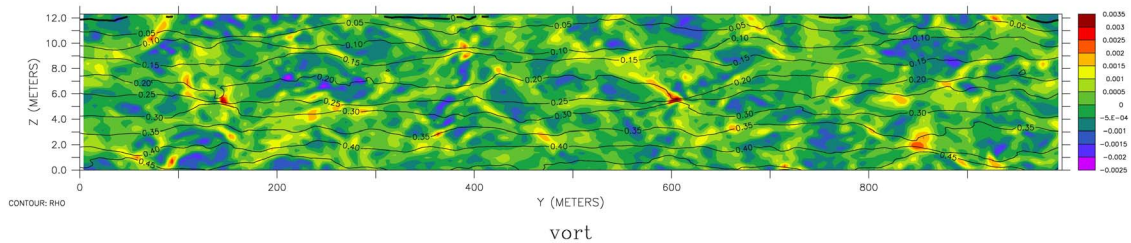


Illustration 1: horizontal cross-section of vertical vorticity field

A horizontal snapshot of the vertical vorticity is shown in Illustration 1. The flow exhibits tight anticyclones surrounded by filaments of cyclonic vorticity, features similar to the ones reported by Capet et al. (2008).



***Illustration 2: vertical cross-section of vertical vorticity.
Isopycnal contours are overlaid in black***

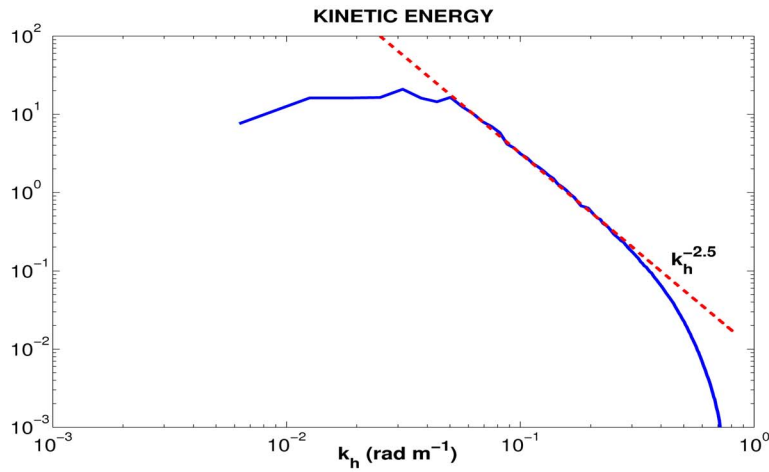


Illustration 3: Kinetic energy spectrum

The kinetic energy spectrum exhibits a -2.5 slope, as compared to -2 behavior reported by others (e.g. McWilliams, 2006). This is shallower than the -3 slopes typically encountered at larger scales and steeper than the -5/3 slopes of the microscale.

IMPACT/APPLICATIONS

Oceanic lateral dispersion on scales of 0.1-10km remains, by and large, not well understood. Dynamical processes at these scales need to be understood in order to develop physically based parameterizations in regional-scale models. For example, the ability to predict pollutant dispersion, given information about the large-scale flow and ambient conditions such as mean stratification would be a very beneficial application of this research.

RELATED PROJECTS

My current NSF grant (through September 30, 2010), entitled *Collaborative Research: Numerical Simulations of Small-Scale Stirring: Internal Waves, Diapycnal Mixing and Horizontal Finestructure* (co-PI: Miles A. Sundermeyer, U Mass, Dartmouth) is closely related to the topic of the ONR Lateral Mixing DRI.