Abstract Submitted
for the DFD12 Meeting of
The American Physical Society

Nonlinear Scale Interactions and Energy Pathways in the Ocean

MATTHEW HECHT, HUSSEIN ALUIE, LANL, GEOFFREY VALLIS, KIRK BRYAN, Princeton/GFDL, MATHEW MALTRUD, ROBERT ECKE, BETH WINGATE, LANL — Large-scale currents and eddies pervade the ocean and play a prime role in the general circulation and climate. The coupling between scales ranging from $O(10^4)$ km down to $O(1)$ mm presents a major difficulty in understanding, modeling, and predicting oceanic circulation and mixing, where the energy budget is uncertain within a factor possibly as large as ten. Identifying the energy sources and sinks at various scales can reduce such uncertainty and yield insight into new parameterizations. To this end, we refine a novel coarse-graining framework to directly analyze the coupling between scales. The approach is very general, allows for probing the dynamics simultaneously in scale and in space, and is not restricted by usual assumptions of homogeneity or isotropy. We apply these tools to study the energy pathways from high-resolution ocean simulations using LANL's Parallel Ocean Program. We examine the extent to which the traditional paradigm for such pathways is valid at various locations such as in western boundary currents, near the equator, and in the deep ocean. We investigate the contribution of various nonlinear mechanisms to the transfer of energy across scales such as baroclinic and barotropic instabilities, barotropization, and Rossby wave generation.

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Date submitted: 12 Aug 2012 Electronic form version 1.4