Dynamics of and Characteristics of Numerical Models of Weakly Nonlinear Flows

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LONG-TERM GOAL

There are two long-term goals of this research program. First, we wish to explore and understand the role of mesoscale and sub-mesoscale currents in ocean circulation and the affect of these flows upon nutrients, plankton, and other nearly passive tracers. This exploration examines mesoscale flows and dynamics both locally and regionally. Within important nonlinear flows, sub-mesoscale features develop in the form of fronts and small vortices where relative vorticity is comparable to the Coriolis parameter. These can be trapped to topographic features, generated by small scale stationary atmospheric phenomena, or freely propagating. The second goal is to develop and apply the best available numerical models and assimilation methodology for regional modeling.

SCIENTIFIC OBJECTIVES

The scientific objectives of this study are 1) to determine the role of jets and eddies in the regional scale (1000 km scale) dynamics of the California Current System, and 2) to assess the utility of the reduced equations (Browning and Kreiss, 1990 and 1992).

APPROACH

To determine the role of jets and eddies in the regional scale dynamics, there are two efforts underway. First, using large regional models to study the geophysical fluid dynamics of a flow which crosses the planetary vorticity gradient yet is neither forced by wind stress curl nor dissipated by boundary friction. Second, data assimilation experiments are conducted to examine these currents as measured during the eastern boundary current field study. These studies use objective analysis of the eastern boundary current experiment data including hydrographic, acoustic Doppler current profiler (ADCP), and drifter data to derive field estimates.

To assess the utility of the reduced equation model, we are integrating the model in open domains with California Current like flows.

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WORK COMPLETED

Idealized studies of the California Current have been completed and studied to understand the flow dynamics. Regional boundary conditions were specified based upon the historical data and 1 to 2 year long integrations were conducted. These model calculations were then analyzed to determine the vorticity dynamics of the calculations.

Data assimilation studies are in progress including data gridding. We have developed the ability to assimilate drifter data, gridding velocities derived from the drifters. these velocities are used to provide absolute flow fields for the dynamic heights calculated from hydrographic data. The combination of ADCP and drifter velocities provides an opportunity for comparing the two data sets.

Our reduced equation studies required the development of a model with open boundaries. As we need to have the reduced equation model and the primitive equation model on identical grids, a C-grid reduced equation model has been developed. Properly implementing the reduced equation model required writing a Poisson equation solver which was consistent with the differencing algorithm applied for the momentum equations. This solver was written and tested and is now being used in the reduced equation model. We are assessing the results of Newberger and Allen (1996), in light of this finding. But also note that the results of their study do not address open boundary situations where the reduced equations are expected to provide a significant advantage.

RESULTS

The important result of this research has been identification of the circulation in the California Current as an unsteady Fofonoff solution to the vorticity equation wherein small scale energy contributed by upwelling filaments results in eastward group velocities. As these filaments cross the planetary vorticity gradient, dynamic vorticity accumulates. Meandering and eddying flow moves the vorticity onshore and exports vorticity to the south. The important implication of this hypothesis is that the California Current will warm in response to increased upwelling winds. Warming is accomplished by shifting the core of the current onshore. Thus, we can link the recent warming of the California Current to the increased upwelling as indicated by the upwelling index.

IMPACT/APPLICATION

We expect that there will be a significant impact upon our efforts to model currents near upwelling coasts. Our study demonstrates the importance of small mesoscale energy upon these systems. Without these upwelling filaments, the nature of the modeled California Current will be significantly different from nature.

TRANSITIONS

There are no current transitions, though we anticipate that the reduced equation model will be available to the community early in 1998.

RELATED PROJECTS

There are four related projects. First, we are examining the behavior of open boundaries in response to idealized phenomena including eddies and waves. This relates to application of the model for California Current studies. Second, the Princeton Ocean model is being applied to the Chesapeake Bay in collaboration with W. Boicourt. G. Browning and I are collaborating on an effort to model coastal boundary currents in large lakes. Finally, a course is being developed for training numerical modelers. The emphasis is upon students from the chemical and biological sciences and is based upon computer based training software (CBT) delivered on CD-ROM.

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