Internal Waves Over the New England Shelf

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LONG-TERM GOALS

Our long-term goal is to better understand processes controlling the horizontal and vertical distribution of internal wave energy over the continental shelf. Emphasis is placed on the near-inertial band. Both the initial response to impulsive forcing and the overall distribution of near-inertial energy are of interest.

OBJECTIVES

We will investigate several aspects of the internal wave field over the New England Shelf, considered to be representative of a general class of broad, gently-sloping shelves. Specifically, we intend to characterize the horizontal and vertical structure of the internal wave field over the shelf and examine the near-inertial response to impulsive wind forcing.

APPROACH

Data from the Nantucket Shoals Flux Experiment (NSFE) and the combined Coastal Mixing and Optics (CMO) and Shelf Break PRIMER experiments will be used to document characteristics of near-inertial waves. Surface forcing fields will be examined to identify events that evoke strong near-inertial responses. Analytical models based on the two-layer formulations of Pettigrew (1980) and Millot and Crepon (1981) will be used as a guide to interpreting the observations. If the observed stratification warrants the additional complexity, a continuously stratified model (Kundu et. al., 1983) will be employed.

WORK COMPLETED

The near-inertial signal was isolated from the CMO current meter data by removing the dominant barotropic tidal constituents and band-pass filtering the resulting record. Surface forcing events warranting further study have been identified for NSFE following Wood and Chapman (1989) and for

CMO/PRIMER using the buoy meteorology and the regionalmodel results described by Baumgartner and Anderson (1999). Aspects of surface forcing relevant to analytical modeling (front translation speeds, storm sizes, translation speeds and durations) were determined for CMO/PRIMER. A hierarchy of two-layer analytical models (of increasing complexity) has been developed and used to explore the oceanic response for a variety of model parameters. There are three models distinguished by the type of forcing: Impulsive forcing (delta function) as described by Pettigrew (1980), propagating step function forcing (representing the leading edge of a front) and propagating pulse forcing (representing the leading and trailing edges of a storm system).

RESULTS

The near-inertial signals extracted from both NSFE and CMO/PRIMER show responses to surface forcing which can be approximated as a two-layer flow. There is a tendency for oscillations in the upper and lower layers to be approximately out of phase. To examine the effects of forcing by atmospheric fronts moving in the offshore direction, we used the propagating step and propagating pulse models. The response was found to be sensitive to the duration of the pulse relative to the inertial period and the speed of the front relative to the barotropic wave speed.

Initial model runs concentrated on simulating storm fronts with offshore translation (cf. Kundu and Thompson, 1985). However, for realistic translation speeds these runs always showed upper and lower layer responses which were nearly in-phase. Modifying the forcing to represent a cross-shelf uniform pulse of finite duration (by using an infinitely fast cross-shelf translation speed) showed an out of phase response more similar to the observations. This idealized forcing is consistent with wind events during CMO, which propagated rapidly alongshore, rather than offshore, and appeared at a given along-shelf location as a nearly instantaneous pulse across the entire shelf. Pulses lasting an integral number of inertial periods produce a highly damped near-inertial response due to destructive interference between waves generated by the leading and trailing edge 'fronts'. In contrast, pulses lasting half an inertial period produce constructive interference and correspondingly strong near-inertial motions.

IMPACT/APPLICATIONS

By extending the analytical work done by previous investigators, we hope to elucidate the principal processes which control the near-inertial response on broad, shallow shelves. Through comparison with observations the ability of simple two-layer models to reproduce the observed response will be evaluated.

TRANSITIONS

None.

RELATED PROJECTS

We are using archived data from NSFE (supported by the National Marine Fisheries Service, the U.S. Geological Survey, and the National Science Foundation) and from the CMO moored array and the Shelfbreak PRIMER experiment (funded by the Office of Naval Research (ONR)). We are sharing data and results with M. Levine and T. Boyd at Oregon State University who are funded by ONR to investigate the coastal internal wave field.

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