DETERMINISTIC AND STOCHASTIC INTERNAL WAVE EFFECTS ON SHALLOW WATER ACOUSTIC PROPAGATION

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An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Major Subject: Mathematics

The original of the complete thesis is on file
in the Rensselaer Polytechnic Institute Library

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January 2007
(For Graduation May 2007)

ABSTRACT

In this dissertation, effects of three-dimensional oceanographic modeling of nonlinear internal waves (NIWs) on three dimensional acoustic propagation in shallow water are investigated. Deterministic and stochastic methods are used to model NIWs. The primary effects of horizontal refraction and vertical acoustic mode coupling are examined.

Three-dimensional adiabatic mode parabolic equation calculations are efficient at solving many range-dependent ocean acoustics problems, such as propagation in regions nearly parallel to the crest of an NIW. Here, strong range dependence can occur due to horizontal refraction of the sound speed field. Pressure fields consisting of one acoustic mode are calculated for two example environments. In each case modal interference patterns demonstrate similar behavior to a horizontal Lloyd mirror. Modeling choices for horizontal Lloyd mirror include amplitude normalization and beam shifting are explored.

At other NIW orientations, non-adiabatic propagation methods may be necessary to accurately describe acoustic behavior because mode coupling can occur due to strong sound speed gradients often associated with NIWs. Discrepancies in 2-D and 3-D calculated results for certain angles defined by acoustic propagation direction and crests of NIWs demonstrate that for certain NIW orientations, fully 3-D methods are required. Furthermore, propagation across the intersection region of two crossing NIWs is investigated.

Random ocean processes can contribute to the breakup of coherence along wavefronts. We examine a fully coupled two-dimensional section of the pressure field to investigate possible mode coupling due to stochastic effects. Coupled mode intensity equations can be approximated by a diffusion equation in range and mode number for large number of propagating modes. A non-constant diffusion coefficient, dependent on mode number, is obtained and approximate solutions are discussed.