Propagation of acoustic-gravity waves in inhomogeneous ocean environment based on modal expansions and hp-FEM

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ABSTRACT

Ocean waves generate acoustic modes in a wide range of acoustic frequencies. Also, energetic acoustic–gravity waves appear as a result of seismic activity in the seabed [1,2]. In this contribution, a coupled mode model for acoustic-gravity waves, propagating in layered waveguides is presented. This analysis, extends previous work for acoustic waves in inhomogeneous ocean environment [3]. The coupled mode system is derived by means of a variational principle and a local mode series expansion, obtained by utilizing variable cross-section eigenfunction systems. These eigenfunction systems are defined through the solution of eigenvalue problems formulated along the waveguide. A crucial factor is the inclusion of additional modes accounting for the effects of spatialy varying boundaries and interfaces. This enhancement provides an implicit summation for the slowly convergent part of the local-mode series. In that manner, the remaining part of the series becomes rapidly convergent, increasing substantialy the efficiency of the method. Finally, the coupled-mode system is numerically solved by hp-FEM on the horizontal plane.

Particular aspects of the method include (a) high order Lagrange Finite Element Methods for the solution of local vertical eigenvalue problems in the case of multilayered waveguides, (b) Gauss type quadrature for the computation of the coupled-mode system coefficients and (c) high order Lagrange Finite Elements, with modal amplitudes as nodal degrees of freedom, for the discretization of the horizontal system. The above aspects makes the present method quite efficient for long range propagation in extended waveguides, such as the ones found in geophysical applications, e.g. ocean basins, as only few modes are needed for the accurate representation of the unknown fields.

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