ACOUSTICS2008/1644
Modeling probability density functions for acoustic propagation through internal waves in shallow water environments

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Acoustic propagation through internal waves is shallow water introduces randomness to the acoustic field in that internal waves are generally incompletely measured and are therefore best understood as random realizations of a stochastic process. Due to the physics of internal waves these environmental perturbations are expressed in a finite number of modes, each of which affects acoustic propagation differently. As acoustic propagation in shallow water is itself confined into modes, a matrix of interaction strengths for both the accumulated phase and the mode coupling may be derived which can be integrated forward along the acoustic path to account for the accumulation of uncertainty. A powerful ansatz for solving this problem is a Polynomial Chaos (PC) expansion of the complex modal amplitudes in the random variables which are the internal wave amplitudes. In this work the PC technique is used to derive the probability density functions of the complex modal amplitudes in the presence of a homogeneous internal wave field, showing good agreement with Monte-Carlo results. The pdfs of the complex modal amplitudes can then be combined to obtain the pressure field pdf as well as various statistics of interest such as the scintillation index. [Work supported by ONR]