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Numerical Modeling Of Acoustic Propagation In A Variable Shallow Water Waveguide

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LONG-TERM GOALS

The long term scientific goal is to better understand the effects of shallow water variability on acoustic propagation at moderate frequencies. Potential sources of water column variability include random background internal waves as well as quasi-deterministic, event-like internal wave packets.

OBJECTIVES

The objectives of the present work are to develop models and improve simulation tools useful in achieving the long-term scientific goal.

APPROACH

Experimental observations are used to guide the development of theoretical models. The models are implemented numerically and compared to experimental results.

WORK COMPLETED

I spent the summer of 1997 as an American Society for Engineering Education-U.S. Navy Senior Faculty Fellow visiting NRL-DC. While there, I was involved in modeling and data analysis of the 1995 Shallow Water Acoustics Random Medium (SWARM 95) experiment [PI: M. Orr, NRL; Apel et al., 1997]. Under current support, I have continued collaborating with investigators at NRL. We have developed a theoretical model to explain the observed rapid decorrelation of the acoustic modes. The model has been tested in numerical simulations and compared to experimental results.

RESULTS

In the model, solitary waves are treated as mode coupling structures moving through the acoustic propagation regime. Decorrelation is a consequence of the changing interference pattern between the modes. The result holds even if dispersion of the internal waves is neglected. In the special case of weak mode coupling, decorrelation occurs when the solitary waves travel an appreciable fraction of the equivalent ray cycle length. When the mode coupling is strong, the interaction between all excited mode pairs must be considered and more rapid decorrelation can be expected.

The model was implemented numerically using a mixed normal mode/parabolic equation approach [Preisig and Duda, 1997]. In collaboration with Altan Turgut of NRL, detailed simulations were performed mimicking the situation at SWARM. Both continuous-wave and broad-band cases were considered. The calculated decorrelation times, on the order of 100 seconds, were comparable what was observed in the experiment [Headrick, 1997].

An interesting phenomenon predicted by the model is the partial recorrelation of the field at time scales of order 10 minutes. Recorrelation is predicted as a consequence of the internal waves moving a distance equal to interference wavelength between dominant mode-pairs. An examination of the SWARM data at these longer time-scales showed evidence of recorrelation, particularly at 224 Hz.

These results were presented at an Acoustical Society Meeting [Rouseff and Turgut, 1998]. An article was published in the procedings of Oceans 99 [Turgut, Wolf and Rouseff, 1999]. A journal article is currently under review.

IMPACT/APPLICATIONS

Variability in the water column affects the temporal and spatial correlation scales of the acoustic field. A capability to model and predict the correlation scales is essential for data analysis and for planning future experiments.

RELATED PROJECTS

Investigators at several institutions are involved in SWARM analysis: NRL, WHOI, the Naval Postgraduate School, and the University of Delaware.

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