8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

Representing Acoustic Field Uncertainty in Ocean Waveguides

***Steven Finette and Yu Yu Khine**

Acoustics Division
Naval Research Laboratory
Washington DC 20375 USA
steven.finette@nrl.navy.mil

Key Words: *uncertainty, acoustics, polynomial chaos, propagation, waveguide*

ABSTRACT

Ocean waveguides are complex dynamical structures that support acoustic propagation over significant distances, from tens to thousands of kilometres depending on the acoustic frequency and ocean waveguide conditions. The propagated fields are typically transmitted by point sources and remotely sensed by an array of hydrophones; received signals are then processed for various purposes, e.g. detection, localization, tracking and classification. Space and time variations in the water column sound speed field, rough boundaries on the ocean surface and bottom, along with sediment properties can significantly distort the emitted acoustic field, degrading its information content. Given complete information concerning the waveguide environment, a forward propagated field can be numerically computed but full information is not available, primarily due to coarse environmental sampling. Therefore, uncertainty in the parameters, boundary conditions and sound speed distribution that characterize the waveguide conditions are effectively propagated to the sensor array along with the computed acoustic field. Simulation-based prediction schemes that ignore environmental uncertainty are therefore compromised with respect to their predictive capability.

To account for incomplete environmental knowledge we treat uncertainty in a probabilistic framework, using Karhunen-Loeve and polynomial chaos basis expansions to describe the uncertain environment and acoustic field, respectively. The forward propagated acoustic field is related to a solution of a narrow or wide-angle parabolic equation and is treated as a random field in this context. Both intrusive and non-intrusive formulations are considered; the former for the narrow-angle parabolic equation and the latter for a wide-angle parabolic equation due to the pseudo-differential structure of the operator. For single frequency propagation, the polynomial chaos coefficients are complex variables. While the intrusive approach yields coupled ordinary differential equations for the coefficients, the uncoupled non-intrusive formulation allows for a solution through multiple solves using an efficient split-step pade solver. For high dimensional problems comprising many uncertain degrees of freedom, a sparse-grid Smolyak integration method is used to compute estimates of the uncertainty coefficients and statistics of the field by evaluating multidimensional integrals over the uncertainty dimensions. Work supported by the Office of Naval Research.