Estimating Refractivity from Propagation Loss in Turbulent Media
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Mark A. Wagner(1), Peter Gerstoft (1), and Ted Rogers(2)
(1) Scripps Institute of Oceanography, La Jolla CA, 92122
(2) SPAWAR, Point Loma CA, United States

This paper estimates lower atmospheric refractivity (M-profile) under non-standard propagation conditions for electromagnetic (EM) waves. Specifically, propagation loss measurements over a scale of tens to hundreds of kilometers to gain information about the existence and potential parameters of any lower atmospheric ducts. The main improvement made on previous inversions is inclusion of range dependent fluctuations due to turbulence in the forward propagation and use of the unscented transform (UT) to estimate the covariance of the turbulent fluctuations. Using this framework the Maximum Likelihood (ML) estimate of atmospheric refractivity has good accuracy, and with information about the prior probability of ducting the Maximum A Priori (MAP) estimate is found. Inclusion of the UT is necessary to capture the range dependence of the covariance matrix whereby the ML and MAP solutions are no longer identical to the minimum mean squared error (MMSE). Additionally, the UT is efficient for estimation of the field amplitude distribution of specified EM waves after inversion and posterior probability distribution calculation. Comparisons are made between inversion methods utilizing MAP and MMSE likelihood functions on propagation loss data simulated by a split step Parabolic Equation (PE). The MAP is found to be statistically more accurate for inversions with the simulated data. A Monte Carlo Markov Chain (MCMC) sampler is used to sample from the likelihood distribution of propagation loss vectors generated from a duct and the corresponding distribution of EM wave propagation loss caused by fluctuations from turbulence is plotted.