Estimating Refractivity from Propagation Loss in Turbulent Media
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This paper estimates lower atmospheric refractivity (M-profile) given an electromagnetic (EM) propagation loss (PL) measurement simulated by a wide angle parabolic equation (WAPE) model. Specifically, height independent PL measurements over a range of 10-80 km are used to infer information about the existence and potential parameters of atmospheric ducts in the lowest 1 km of the atmosphere. The main improvement made on previous refractivity estimations is inclusion of range and height dependent fluctuations in atmospheric refractivity (to simulate turbulence) in the forward propagation model. Two models of turbulence are tested, one generating homogeneous turbulence according the Von-Karman spectrum at all heights and ranges, and another 'inhomogeneous' model, inspired by recent results from Large Eddy Simulation (LES) where turbulence is increased in the duct interface. Monte Carlo methods are used to estimate the mean and covariance of the PL vector being influenced by turbulence, which are fed into a Gaussian likelihood function and inverted by finding the parameters of the maximum likelihood (ML) M-profile using a genetic algorithm (GA). Distributions of PL simulated under homogeneous and inhomogeneous turbulence models are shown to be significantly different, particularly for M-profiles of ducts with small M-deficits known as elevated ducts. Comparisons were made between inversions performed on PL simulated with homogeneous and inhomogeneous turbulence. It was found that an inhomogeneous turbulence model allowed for significantly higher inversion accuracy for elevated ducts, though it is unknown if such a model accurately describes the distribution of turbulence in the atmosphere. The results suggest that accurate modeling of turbulence is a key limiting factor in refractivity inversion accuracy.