Preliminary Study on Use of Ensemble Weather Prediction Data for Inversely Determining Atmospheric Refractivity in Surface Ducting Conditions

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Prediction of surface ducts enables improved system performance characterization for numerous communication and sensing technologies that rely on the propagation of electromagnetic (EM) waves, such as radar. Direct measurement and simulation of these conditions is challenging due to the complex air-sea exchange processes and turbulent nature of the marine atmospheric boundary layer. In addition, EM propagation prediction requires detailed environmental data at high spatial resolution over long distances. To address these challenges, inverse methods of determining atmospheric refractivity have developed over the past couple decades (Karimian et al., 2011), which utilize radar measurements and radar propagation models to infer information about the refractive environment. Prior research has shown that ensemble weather forecasts often encompass the measured surface duct atmospheric refractive conditions despite no single (deterministic) forecast matching measured conditions (Zhao et al., 2016). Methods that merge weather prediction and inverse methods have shown great promise in improving the predictions from either method performed independently (Karimian et al., 2013).

In this study, we perform a preliminary analysis quantifying the potential accuracy gains associated with incorporating information from ensemble weather predictions into an inversion process to determine atmospheric refractivity in surface ducting conditions. This study uses data from the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) and instrumented helicopter (helo) measurements taken during the Wallops Island Field Experiment to evaluate the use of ensemble forecasts in refractivity inversions. Helo measurements and ensemble forecasts are optimized to a parametric refractivity model, and three numerical experiments are performed to evaluate whether incorporation of ensemble forecast data aids in more timely and accurate inverse solutions using genetic algorithms. The results suggest that using optimized ensemble members as an initial population for the genetic algorithms generally enhances the accuracy and speed of the inverse solution; however, use of the ensemble data to restrict parameter search space yields mixed results. Inaccurate results are related to challenges associated with parameterization of the ensemble members' refractivity profile and subsequent extraction of the parameter ranges to limit the search space as well as treatment of the surface refractivity.